Final Report on Braille: Optimum Size and Spacing for Introducing Blind Adults to the Braille Code

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Abstract

Forty adventitiously blind adults with little or no knowledge of braille were administered, in random order, 12 different stimulus matching tests to determine the optimum size and vertical and horizontal spacing for tactual discriminability of braille shapes. These tests represented all possible combinations of three variables: (a) standard or enlarged braille; (b) one, two, or three spaces between braille characters; and (c) one or two skips between lines. Data were collected on both speed and accuracy. Analysis of variance of test scores revealed that regardless of diabetic condition, age, or occupation, subjects were equally accurate, but time was significantly faster with standard size braille and three spaces between characters. Subjects 70 years old and older and those with no knowledge of braille scored significantly lower regardless of the variables. These findings suggest that material in standard braille with three spaces between characters and lots of practice is most effective initially with adults.

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Introduction

Research on the optimum size and spacing of braille has a long history (Nolan and Kederis, 1969). In 1913 the Uniform Type Committee was not only trying to decide whether to adopt some form of braille or some other embossed system of reading and writing for the blind, but they were also trying to answer questions such as, What size of type is most easily read? and, What is the best method of spacing for American Braille? During the course of this research, it was concluded that more time was taken and more errors were made using small type and close spacing. By 1920 Latimer was reporting that interdot spacing of .090" within the braille cell, intercell spacing of .025" in adjacent cells, and interline spacing of .398" in adjacent lines seemed best when tried with sixty-four braille readers, thirty-six of whom were sixteen years old or older. In 1928 Maxfield reported that shape and height affect the perception of braille dots and that "a rounded dot, shaped like half a cone, is the most generally efficient." In 1958, following a study by Meyers and Ethington and a small-scale replication by Calvin and Clark, a more in-depth replication by Meyers, Ziekel, Ashcroft, Clark, and Calvin was done and the following dimensions for braille reading were found to be near optimum:

.090" for interdot spacing
.160" for intercell spacing
.220" for interline spacing

These dimensions were standardized and are still in use today in American standard braille.

Even though these dimensions were established as near optimum for the experienced braille reader, often instructional braille programs initially made use of some form of enlarged braille. Enlarged braille has been improvised from such things as cupcake pans and tennis balls or marbles fit in holes. It has been included in some commercially produced braille programs such as Patterns: The Primary Braille Reading Program, which makes use of the Swing Cell and pegs, and the Braille Series, 1960, which uses four sizes of braille very much enlarged, moderately enlarged, slightly enlarged, and standard sized to introduce the braille code. Because of the interest in enlarged braille, Howe Press now sells braillers and slates and styluses for producing braille in three sizes--jumbo, large cell, and standard--based on consumer preference research. Tobin (1971) reported that in a survey of British braille teachers of adventitiously blind adults, the majority (53%) favored the use of enlarged braille during initial braille instruction. Newman (1984) studied the effect of the size of the braille cell on the rate of learning the names of braille symbols using eighty sighted male subjects enrolled in psychology at North Carolina State University and concluded that using large braille facilitated learning. On the other hand, Harley, Pickert, and Morris (1985) found no significant difference in the ability of 10 blind diabetics with diminished tactual sensitivity to discriminate standard and enlarged braille characters when given unlimited time.

Indications are that spacing around the braille cell plays an important role in initial braille recognition. Books for young beginning braille readers are generally double-spaced (interlined) in accordance with the standards for braille books set forth by the American Association of Instructors of the Blind and the American Association of Workers for the Blind. Misbach (1954) and Hoffman and Cook (1970) suggested double-spacing both between lines and between words to aid young braille readers in discrimination. Rehabilitation counselors have indicated recently that they seem to have better results when braille is presented to adults initially with even more space around each braille character. Heller and Mitchell (1985), using 60 sighted undergraduates as subjects, concluded that beginning braille readers might profit from extra space between the braille characters comprising words. Research is still needed to determine the optimum size and space between braille characters both vertically and horizontally for blind adult beginning braille readers.

Purpose

The primary purpose of this study was to determine the optimum size and vertical and horizontal spacing for introducing adventitiously blind adults to the braille code, particularly those who were diabetic or elderly.

Subjects

Forty adventitiously blind adults with little or no knowledge of braille served as subjects for this study. Participants were sought who had not yet begun braille instruction or who were just beginning braille instruction and had not yet progressed past the alphabet. Before beginning the tests, subjects were asked to complete a questionnaire about themselves and their knowledge of braille. This questionnaire is shown in Appendix A. Participants who knew too much of the braille code, who did not have sufficient tactual sensitivity to complete the tasks, who did not choose to complete the tests, or who, because of illness were unable to participate, were eliminated from the study.

Table 1 shows that the 40 subjects came from five different rehabilitation agencies, with the majority from The Greater Pittsburgh Guild for the Blind and The Carroll Center for the Blind in Massachusetts. The ages of subjects varied greatly. While the greatest proportion of people were in the 24 to 33 age range, a number of significantly older individuals were also present: six subjects were more than 70 years old. Educational attainment also varied considerably. Most subjects were high school graduates, but a few had post-baccalaureate credits and some had not finished elementary school.

Information from the participants' questionnaires was used to classify their occupational statuses. This classification was very subjective. Table 2 shows frequency distributions for two different versions of the occupational status variable, labeled OCC1 and OCC2. In both cases there was roughly an even split between persons who could be classified as skilled or unskilled in occupation. The number of subjects in the "Other" category was the same in both OCC1 and OCC2. These were two homemakers and one person who listed no occupation. Also the same number of "Unskilled" people was recorded--16. These were people working in the type of job requiring no complex training or education (i.e., dishwasher).

The difference between variables OCC1 and OCC2 related to the treatment of workers who were skilled in some way. In variable OCC1, the final category was simply "Skilled." This covered any job or profession requiring special training or a college degree. For variable OCC2, an attempt was made to distinguish between professional-level skilled jobs (e.g., teacher) from managerial or technical-level skilled positions (e.g., store manager).

The categories for variables OCC1 and OCC2 had code numbers associated with them: for OCC1 these ranged from 2 (Skilled) to 0 (Other); for OCC2 these ranged from 3 (Skilled/Professional) to 0 (Other). In Appendix B these codes are shown for each of the 40 subjects.

Among the most common causes of vision problems were diabetes and glaucoma. The average time diabetics were afflicted with the disease was about 18 years. This information is shown in Table 3.

Data on two variables related to visual impairment are summarized in Table 4. About three-fourths of the subjects reported that their sight was lost gradually rather than suddenly. The average amount of time that sight had been lost was about four years.

Finally, an attempt was made to relate the subjects' previous knowledge of braille with their performance on the braille tests. Much the same situation prevailed for braille knowledge as for occupational status. Again, information from the sheets on which subjects reported how much braille they knew was used. Table 5 shows frequency distributions on the following two variables: Braille Knowledge (BK1), which had only three categories, and Number of Braille Letters Known (BLET), a variable ranging from 0 to 28. For this latter variable, the number of letters the person claimed to know were simply counted. For example, persons stating that they knew letters *a* through *e* were given a 5. In cases in which persons stated that they knew the entire alphabet and something else (e.g., punctuation), they were given more than 26 points, viz., 27 or 28 points.

A certain amount of judgement was required in classifying subject-provided information. For example, one subject claimed that she knew the entire alphabet, but that she was "very rusty." What does one do with this information? It would seem that the analyses for the two braille knowledge variables must be viewed as suggestive rather than definitive. The categories for variable BK1 had code numbers associated with it: these ranged from 3 (Whole Alphabet) to 1 (No letters). For variable BLET, category values ranged from 0 to 28. In Appendix C, codes for BK1 and category values for BLET are shown along with the occupations listed for each of the 40 subjects.

Method

Materials

Materials consisted of 12 different braille discrimination tests representing all possible combinations of three different variables: (a) size of braille--standard or enlarged matrix with standard sized dot, (b) horizontal spacing between characters--one, two, or three cells, and (c) vertical spacing between lines--one or two line skips. The tests were as follows:

Test	Code	
1	S11	Standard, 1 space between characters, 1 skip between lines
2	S21	Standard, 2 spaces between characters, 1 skip between lines
3	S31	Standard, 3 spaces between characters, 1 skip between lines
4	S12	Standard, 1 space between characters, 2 skips between lines

5	S22	Standard, 2 spaces between characters, 2 skips between lines
6	S32	Standard, 3 spaces between characters, 2 skips between lines
7	E11	Enlarged, 1 space between characters, 1 skip between lines
8	E21	Enlarged, 2 spaces between characters, 1 skip between lines
9	E31	Enlarged, 3 spaces between characters, 1 skip between lines
10	E12	Enlarged, 1 space between characters, 2 skips between lines
11	E22	Enlarged, 2 spaces between characters, 2 skips between lines
12	E32	Enlarged, 3 spaces between characters, 2 skips between lines

Each of the 12 tests contained 15 stimulus matching items on two standard-sized braille pages. The first eight items were on page 1, and the remaining seven were on page 2 of each test. The first nine stimuli consisted of one cell; the next three, two cells; and the last three, three cells. Each item contained the stimulus and four answer choices, one of which matched the stimulus.

Although items for each condition were not identical (to prevent subjects from "learning the test"), efforts were made to construct similar types of items based on perceptual error types as identified by Ashcroft (1960), namely:

1. missed dot
2. added dot
3. reversal
4. vertical alignment
5. horizontal alignment
6. ending

Because alignment errors, particularly those involving vertical alignment, are difficult even for experienced braille readers (Henderson, 1961), items using such foils were avoided. The 44 one-cell braille units used in test construction are shown in Appendix D. Ending problems are inherent only in items consisting of combinations of two or more cells; therefore reversals, missed or added dots, or similar tactual configurations were concentrated at the ends of these items.

Two-thirds of the items on each test were purposefully constructed to reflect these criteria; the other third contained randomly selected foils. For these foils or distractors, each of the remaining 43 one-cell braille units shown in Appendix D had an equal chance of being selected. The items with randomly selected foils were evenly distributed among the one-, two-, and three-cell items.

A print copy of the braille test materials is found in Appendix E. It shows the 15 items used in each of the 12 subtests with items marked to indicate if foils were randomly or purposefully selected and the types of errors represented by the foils.

Procedure

Prospective subjects, usually recommended by the agency itself, were briefed individually on the purpose of the study and asked to participate. Appendix F shows the material that was used for this introduction to the study. At this time subjects also gave the information on such things as age, cause of blindness, occupation, and knowledge of braille needed to complete the questionnaire mentioned earlier (see Appendix A). Individuals who reported knowing braille contractions, word signs, or short-form words were eliminated from the study.

Next subjects were given a general introduction to the type of activity involved using four practice items printed on two braille pages, three on page 1 and one on page 2. These items are shown in Appendix G. The four practice items consisted of embossed point symbols which had previously been proven to be tactually discriminable (Nolan and Morris, 1971; Barth and Davis, 1984). This activity allowed the investigator to give additional help as needed and to observe the participants' tactual skills before beginning the actual test items.

Finally each subject was tested individually by one of two investigators using the specially designed test materials described earlier (see Appendix E). Appendix H gives the directions which the investigators used for administering both the practice items and the actual test items. Data collected on the actual test items included the number correct and the total amount of time required for each of the 12 tests. Subjects were allowed as much time in as many sessions as they needed to complete the tests. The order of presentation of the material representing the various test conditions was randomized to prevent a practice effect.

Results

Analyses of Data

Number correct on the twelve tests. The number of correct items was counted for each subject and averaged for each of the 12 tests. Table 6 shows mean scores on five different categories of test items. The most complete category was "All items." This was the average over all 15 items per test (i.e., scores could range between 0 and 15). Then the averages are shown for one-cell, two-cell, and three-cell items, respectively. Score ranges for these categories were 0-9, 0-3, and 0-3. Finally, two-cell items and three-cell items were combined (score range 0-6).

Data from each of these item types were subjected to analysis of variance (ANOVA) to determine whether any particular condition or combination of conditions led to superior performance. The type of ANOVA used was a repeated measures model with three within-subject variables: size of braille (standard or enlarged), space between characters (one, two, or three), and number of skips between lines (one or two). This 2 x 3 x 2 ANOVA yielded three main effects, three two-way interactions, and one three-way interaction. Tests of null hypotheses for the main effects answered the following three questions:

1. Were there significant differences in mean scores on tests using standard braille versus those using enlarged braille?

2. Were there significant differences in mean scores on tests using one space, two spaces, and three spaces between characters?

3. Were there significant differences in mean scores on tests using one skip versus two skips between lines?

The four interaction effects showed whether there were any significant sources of variance due to some combination of the conditions represented by the three main effect variables.

This experimental design model had the usual ANOVA assumptions (e.g., normally distributed scores, homogeneity of variance among groups). In addition, data for effects involving the variable with three levels (viz., the space main effect and the interaction effects called Size x Space, Space x Skip, and Size x Space x Skip) were required to meet the circularity assumption. An adjustment procedure recommended by Kirk (1982), testing experimentally obtained *F* ratios against Greenhouse-Geisser adjusted critical *F* values, was employed to prevent any biases which may have occurred due to violation of the circularity assumption.

Tables 7 and 8 show ANOVA summaries for the five item types that were shown in Table 6. Using a statistical significance criterion of .05, there were no significant differences among means based on all 15 items per test nor were there differences among means based on one-cell items only. In fact, throughout all the analyses on mean numbers of items correct, there were only two significant F ratios: in the ANOVA for two-cell items (Size x Space effect) and in that for three-cell items (Skip effect).

Figures 1 and 2 graphically portray both of the significant effects. Figure 1 shows the nature of the interaction between the size and space between variables. When subjects read braille with two spaces between characters, more two-cell items were correctly identified with enlarged braille than with standard braille. However, with three spaces between characters, standard sized braille led to a higher mean score on two-cell items than did enlarged braille. Figure 2 shows the skip main effect for three-cell items. There was a higher mean score on three-cell items for those tests with two skips between lines (1.57) rather than those with one skip (1.41).

Time to complete the tests. Persons in the study could work as long as necessary in completing each of the 12 tests. The number of minutes required for each test was recorded for each person; mean scores are shown in Table 9 and an ANOVA summary in Table 10. There were two significant main effects, for Size and for Space between characters.

Figures 3 and 4 are diagrams of these effects. As can be seen in Figure 3, the mean number of minutes to read enlarged braille (11.46) was significantly greater than the time to read standard size braille (10.56). Figure 4 shows the differences in time among tests having one, two, and three spaces between items. Tests with three spaces between items took an average of 10.54 minutes, while those with one and two spaces between items took 11.35 and 11.13 minutes, respectively.

Table 11 shows two comparisons on mean number correct across the 12 tests: nondiabetic versus diabetic and younger versus older subjects, those who were 70 years of age or older. Individual t tests revealed no statistically significant differences ($p = .05$) between diabetic and nondiabetic subjects on the 12 test scores. Neither did multiple discriminant analysis reveal any significant difference when a test was made of the canonical discriminant function (12 df, $\chi^2 = 5.53$, $p = .94$). Finally, a split-plot factorial ANOVA, with diabetic/nondiabetic as the between group variable and standard braille tests and enlarged braille tests as the within subject variables, showed no statistical significance for any of the three F ratios calculated. Thus, in three statistical procedures applied to data from diabetics with enough tactual sensitivity to complete the tests and to nondiabetics, no evidence was found of differences between these groups on ability to correctly identify items on the 12 tests.

In contrast, there were differences between older and younger subjects. Individual t tests revealed significantly superior performance (p .05) by younger subjects for all 12 tests. This was further confirmed by a multiple discriminant analysis (12 df, $\chi^2 = 31.31$, $p < .01$ for the canonical discriminant function). The disparity in the numbers of older and younger subjects (6 and 34) made statistical testing of any interactions difficult. Had a sufficiently large number of older subjects been available, it might have been possible to detect interactions indicating that older subjects had particularly low performance on certain combinations of treatments. However, even with the limited number of older subjects in the present study, the "main effect" of age was quite evident. It is a safe generalization that age acted as a general depressant on performance across all 12 treatment combinations.

Mean number of minutes to complete the tests for the four comparison groups, diabetic versus nondiabetic and younger versus older subjects are shown on Table 12. Comparisons of diabetics versus nondiabetics and of older versus younger subjects were made by individual t tests across the 12 tests and multiple discriminant analysis using the 12 scores as predictor variables. No statistically significant effects (using $p < .05$) were found.

Occupational status variables OCC1 and OCC2 were used in several analyses to determine whether they were related to test performance. On variable OCC1, the mean score (i.e., total correct on the 12 braille tests) was 108.2 for Unskilled and 106.5 for Skilled. The t value of 0.15 was statistically significant (35 df, $p = .05$). Using OCC1 for another dependent variable, no significant difference was found in the average amount of time taken to complete the tests: 139.1 minutes for Unskilled versus 122.3 minutes for Skilled ($t = 0.74$, 35 df, $p \geq .05$). When the variable OCC2 was tried as an independent variable, similar results occurred. One-way analyses of variance (ANOVA) with the three categories, Unskilled, Skilled/Managerial, and Skilled/Professional, revealed no significant difference among groups on mean scores for test performance (number correct) or time to complete the tests (minutes). In summary, there was no evidence that occupation was significantly related to the performance of subjects on the braille reading tests.

A series of 13 one-way analyses of variance (ANOVA) were performed with Braille Knowledge (BK1, 3 categories) as the independent variable and test scores on braille tests 1 through 12, plus total score, as the dependent variables. Since 13 ANOVA were performed, a protection against excessive commission of Type I errors was introduced by using .0039 as the alpha level for each ANOVA. Using this conservative criterion, significant differences among groups were found on braille tests 3, 6, 9, and the total score based on all 12 braille tests.

For the ANOVA based on the total across 12 braille tests, the obtained $\underline{F}$ was 6.67 ($\underline{p} < .0039$, 2, 37 df). This was followed up by a Tukey HSD multiple comparison procedure (alpha = .05) to determine which means differed from which. It was found that subjects who said they knew no braille letters got an average score on the 12 braille tests of 70.6. This was significantly lower than the mean score of 105.9 for people who knew some letters and also significantly lower than the mean 130.7 for those who knew the whole alphabet. Thus, the variable Braille Knowledge did seem to be linked with performance (i.e., number correct) on the braille tests: those who claimed no knowledge of braille did do poorer than those claiming some knowledge.

A one-way ANOVA was also performed using BK1 (3 categories) as the independent variable and total time to complete the 12 braille tests as the dependent variable. No statistically significant relationship was found between Braille Knowledge and time to complete the tests ($\underline{F} = 0.21$, $\underline{p} = .81$, df + 2, 37).

The variable Number of Braille Letters Known (BLET) was used in several analyses. Since BLET had a comparatively wide range and could be viewed as close to being intervally scaled, correlational analysis was employed with this variable. It should be noted that for three subjects, the only information available was that they knew "some" braille letters. These persons were arbitrarily given a value of 9 on variable BLET, believed to be a fairly conservative and defensible number.

The Pearson correlation coefficient between BLET and total score on the 12 braille tests was $\underline{r} = .4746$ ($\underline{p} < .001$). A scatter diagram (including the best fitting straight line through the data) is shown in Figure 5. The positive relationship revealed here shows that those subjects who knew fewest braille letters tended to get a lower total correct score on the 12 braille tests. Those who knew more braille did comparatively better. This relationship could be classified as low to low-moderate in strength. The coefficient of determination, *r* squared, is .225; this is the proportion of variance in total correct test scores that can be accounted for by Number of Braille Letters Known.

(Just for the sake of curiosity, the data were recorded so that subjects who knew "some" letters were classified as knowing 5 rather than 9. The *r* obtained was .4519, which is close to the .4746 reported above.)

When the variable BLET was used in a correlational analysis with total amount of time used to complete the 12 braille tests, an *r* of .0723 was obtained. Using a criterion of $p = .05$, this was not statistically significant. Thus, there was no evidence that Number of Braille Letters Known related to how long it took subjects to complete the braille tests.

The results obtained for variables BK1 and BLET were similar. In both cases, evidence was found that those who knew some braille did relatively better on the braille tasks (they got more of the multiple choice items correct). However, there was no evidence that braille knowledge related to how long it took subjects to complete the tests.

Analysis of errors. Five different kinds of errors were recorded and summarized. Table 13 shows mean scores on each of the 12 tests for top line skips, medial line skips, bottom line skips, multiple answers, and selection of first shape. The most common type of error was medial line skip. Some of the other types of errors occurred infrequently; for some treatment combinations some kinds of errors never occurred.

The test materials used in this study had nonstandard top and bottom margins which might have produced additional top and bottom line skip errors. The materials had to be made this way in order to vary the size and spacing of the braille while keeping the number of items on each page constant. Since more medial line errors were possible and medial line errors were not confounded by the margin variations, analysis focused on medial line skip errors. An ANOVA was performed to determine whether any type of braille presentation was most associated with this relatively large number of medial line skip errors.

As can be seen in Table 14, all three effects and one interaction effect (Size x Skip) were statistically significant ($p <$ .05). Figures 6, 7, and 8 show graphic portrayals of the main effects. The average number of medial line skip errors was greater for standard braille (mean errors = .51) than for enlarged braille (mean errors = .28). The average number of medial line skip errors was greater for two and three spaces between characters (mean errors = .49 and .48) than for one space between characters (mean errors = .23). The last main effect revealed that one skip between lines led to more mistakes (mean errors = .65) than did two skips between lines (mean errors = .15).

Figure 9 shows the significant interaction effect for medial line skip errors. The nature of the interaction can be summarized as follows. When standard size braille was used, the number of errors was about the same with both one and two skips between lines. However, when enlarged braille was used, a larger number of errors occurred at one skip between lines than at two skips between lines.

Item analysis. An item analysis was performed on the 12 tests to determine their psychometric properties. Table 15 shows the results of the first analysis which involved looking at all 15 items within each test. Shown are basic descriptive statistics, as well as information on the items and the alpha coefficient, a measure of internal consistency reliability. Since each test had 15 items, scores (i.e., number correct for each subject) could range between 0 and 15. As can be seen in the table, the first test had a mean of 9.10 and a standard deviation of 2.92. The mean item mean was the average proportion correct for the 15 items within the test. For test 1, the value was .61. Expressed as a percentage this is 61%. In other words, for the 15 items in test 1, the average percentage correct was 61%.

After the mean item mean are two columns showing the most difficult item(s) and the easiest item(s), respectively. For the first test, the minimum item mean was .35; that was the proportion correct obtained on items 11 and 15 of test 1. They were the hardest items within the test. (The item numbers are shown in parentheses after the .35.) The maximum item mean was .88 obtained for item 8: it was the easiest item in test 1. Finally, the alpha coefficient was .66. This is an index of internal consistency reliability. It ranges between 0 and 1.00, and the closer alpha is to 1.00 the more the items are related to one another, that is, the more they are measuring the same thing.

Table 16 has a similar set-up to Table 15. The difference is that in Table 16, only the first nine items per test (single cell braille items) were included in the analyses. Since the range of possible scores decreased, the means and standard deviations were lower. The mean item means tended to be higher than in Table 15 because two-cell and three-cell items were eliminated and they were the hardest items. Also, the minimum item means (the proportion correct for the hardest item(s) within a test) were higher, again, because only one-cell items were included. Finally, alpha coefficients decreased somewhat. This was understandable, given that the value of alpha is partly related to the number of items in a test--the greater the number of items, the higher the coefficient.

Each subject in the study was tested on 180 items (12 tests x 15 items per test). For the entire set of 180 items taken together, the easiest and the hardest items were identified; these are displayed in Tables 17 and 18. As can be seen at the top of Table 17, the easiest item was number 3 within test number 5, the one-dot braille shape for the letter _a_. It was correctly answered by 97.5% of the sample (39 of the 40 subjects). At the bottom of Table 18, one can see that the hardest item was item 11 within test number 12, an item consisting of the three-dot braille unit _ing_ plus the three-dot letter _f_. Only 15% of the sample (6 of 40 people) answered it correctly. Not surprisingly, almost all of the easiest items were one-cell items and almost all of the hardest items were two- or three-cell items.

Analysis of foils. Several analyses were pursued in order to examine the effectiveness of various types of foils (i.e., distractors). First, the effectiveness of randomly chosen versus nonrandom foils was studied. Within each of the 12 tests, three of the one-cell braille items had distractors that were chosen at random and the remaining six one-cell items had distractors purposefully chosen by the researchers. It was hypothesized that items with randomly chosen foils would be easier than those with nonrandom foils.

In order to test this hypothesis, the average was taken over random foil items and the nonrandom foil items for each subject. This was done separately for each of the 12 tests and then for all the tests together. A series of 13 dependent t tests were performed to determine if the average item means were different. Generally speaking, support was found for the hypothesis: it appeared that random foil items were, indeed, easier. Relevant data are shown in Table 19.

Shown in the table are means for random and nonrandom foil items and the t statistic calculated to test whether the means were different. For example, in test 1, the mean score for the two types of items was exactly the same (.6750) for both types of items. This led to a nonsignificant t of 0. For most of the tests, however, the average item means were about .10 higher for random rather than nonrandom. Means from tests 5, 6, 7, 10 and 12 were significantly different. Finally, the average over all 12 tests showed that the average item mean for random items was .7243 versus .6205 for nonrandom (t = 8.05, 39 df, $p < .0039$). This means that, on all of the 12 tests, the average proportion correct for the random foil items was .7243 in contrast to .6205 proportion correct for nonrandom foil items. The 40 subjects were more likely to get an item right when its distractors were chosen at random.

(Since 13 _t_ tests were performed, a conservative adjustment procedure was used to lower the alpha level for each _t_ test. Thus, the probability of a false claim of statistical significance was minimized.)

Further analysis of foils involved determining which type of foil was most attractive. In other words, what type of distractor most often was mistaken or incorrectly chosen. Three different kinds of distractors were studied: reversal (R), dropped dot (-1), and added dot (+1). Tables 20 through 23 summarize these data. Only the nine one-cell items within each test was analyzed since the two- and three-cell items were often confounded with more than one type of error. For example, one foil could contain both a dropped dot shape and an added dot shape or a reversal could also be an ending error.

Table 20 contains data on the reversal (R) foil. The first column, labeled an R total, gives information on all the one-cell items involving and an R foil. There were 57 such items. The number of times an R foil was chosen was 347. The number of _possible_ choices for the 57 items is 2280. This was obtained by simply multiplying the number of items by the number of subjects in the study: 57 x 40 = 2280. This represents a ceiling value--if every subject always picked an R foil when confronted with one, there would have been that many times it would have been chosen. The actual number chosen, 347, was, of course much less than the maximum. The ratio of the number of times chosen to the number of possible times chosen provides an index of the attractiveness of the foil. The higher the number, the more attractive (i.e., effective) the foil. For R total, 347/2280 = .152, meaning that 15.2% of the time an R distractor could have been chosen, it actually was chosen.

The R total data just described covers all occasions when a reversal (R) foil was in an item. However, the R appeared in different contexts, and so contextual effects of the R foil were studied. The second column of Table 20 shows R alone--this means items in which the only distractor used was R (i.e., there were no dropped dot or added dot foils in the item). There were 11 such items. For this situation, the 40 subjects picked the R distractor 61 times. The maximum number of possible times it could have been chosen was 11 x 40 = 440. So the proportion of actual to possible choices was 61/440 = .139. Again, this proportion should be interpreted as an indicator of the effectiveness of the distractor. The remainder of Table 20 shows similar-type data for three other situations: (a) when an R foil appeared in an item that also had a dropped dot (-1) foil, (b) when an R foil appeared in an item that also had an added dot (+1) foil, and (c) when an R foil appeared in an item that also had both a dropped dot (-1) and an added dot (+1) foil. The table reveals that subjects picked an R foil for .197, .120, and .140 proportions of the time for these three different situations.

Tables 21 and 22 are patterned after Table 20. They show data for the other two types of foils considered: dropped dot (-1) and added dot (+1). Again, the proportions shown at the bottom of each table provide an index of the effectiveness of a given type of foil/item combination. Finally, Table 23 was constructed to make it easier to understand Tables 18 through 20. There are no new data in Table 23. It simply shows the proportions from the bottom of Tables 20 through 22 in rank order from highest to lowest. The most effective foil (i.e., the most attractive type of wrong answer situation) was a reversal (R) foil when in an item also containing a dropped dot foil. The R foil was chosen .197 of the possible times it could have been chosen. The least attractive foil was a dropped dot (-1) when in an item also containing a reversal and an added dot (+1) foil. For such items, the dropped dot (-1) foil was only picked 8.1% of the possible times.

Summary of Findings

Presented below are the major findings of the study in brief form. Included are some interpretations of the data analysis.

1. Persons got about the same number of items correct regardless of the size of braille used, the space between characters, or the skips between lines.

2. Enlarged braille took a significantly longer time to discriminate than standard size braille. The average time to read an enlarged braille test was 11.46 minutes, but it was 10.56 minutes for standard braille.

3. Three spaces between items produced faster discrimination times.

4. With two cell items, both the combinations of three spaces between items and standard sized braille and two spaces between items and enlarged braille led to higher mean scores.

5. For three cell items, there was a higher mean score with two skips between lines.

6. There was no evidence that the 11 diabetic subjects were a distinct subgroup. They did not differ significantly from nondiabetics in number of correct items on the tests or amount of time to complete the tests.

7. Subjects older than 70 years of age got fewer items correct than did the younger subjects. This was true for all 12 tests.

8. Occupational status was found to be unrelated either to performance (i.e., number correct) on the braille tests or to time to complete the tests.

9. Knowledge of braille was positively related to performance on the tests; the more braille claimed to be known by persons, the better they did. However, no relationship was found between knowledge of braille and how long it took to complete the braille tests.

10. A type of error--medial line skip--occurred more frequently in some treatment conditions than others. More of this type of error occurred with (a) standard braille rather than enlarged, (b) two or three spaces between characters rather than one space, and (c) one skip between lines rather than two skips.

11. When standard size braille was used, the number of medial line skip errors was about the same with both one and two skips between lines; however, when enlarged braille was used, a larger number of errors occurred with one skip between lines than with two skips between lines.

12. Analysis of variance of test scores revealed that differences among treatment conditions were relatively minor. In terms of how many test items were correctly identified, subjects performed similarly on the 12 different tests. It is true that statistically significant effects were obtained--one for two-cell items and one for three-cell items. However, the 12 combinations of treatment conditions (involving size of braille, space between characters, and space between lines) did not seem to affect performance to an extent that was practically important. Alpha reliability coefficients ranged from .60 to .82, indicating moderate reliabilities for the 12 braille tests.

13. Item analysis revealed that almost all of the easiest items were one-cell items and almost all of the hardest items were two- or three-cell items.

14. It was found that those items with randomly chosen foils were easier than items with purposefully selected foils.

15. Analysis of types of foils showed that some types were more effective than others. The most attractive type was a reversal when used in a multiple-choice item that also contained a dropped dot foil.

Discussion

Conclusions

Since size of braille made no difference in subjects' accuracy, regardless of diabetic condition, age, or occupation, it does not seem to matter whether standard or enlarged braille is used. However, since speed is an important consideration in braille reading and standard size braille proved to be significantly faster for subjects to discriminate than enlarged braille, there is a real advantage to using standard size braille. Also, most material is printed in standard size braille, so if initial instruction is in standard size braille, there is no need for time-consuming transitioning from one size to another or possible relearning. To read braille tactually, the reader must be able to discriminate a pattern of embossed dots in a small area near the tips of the fingers and standard size braille seems to fit this small area best. For all these reasons, standard size braille seems to be the preferable choice for initial braille instruction.

This study additionally suggests that using three spaces between characters produces faster discrimination and therefore would be better for initial braille instruction. With two-cell items (which might be thought of as short words), subjects using standard sized braille continued to discriminate better when three spaces were left between combinations. When introducing single shape braille units or words in isolation, this should be no problem. However, conventional braille usually is written with only one space between words in phrases and sentences. If three spaces were used for initial instructions, this would not only be a departure from the norm, but would also require relearning for conventional reading. Since knowledge of braille does improve performance, perhaps by the time students are ready to read words in phrases and sentences, they might be able to discriminate just as well with conventional spacing.

Both one and two line skips were equally acceptable for beginning braille readers discriminating between one- and two-cell combinations. It was only for three-cell items (which subjects may not have been ready to deal with yet on this test) that two skips between lines improved discrimination. Since the braille reader eventually needs to be able to read material with no line skips, it seems advantageous to use the traditional one line skip and to expect that by the time the reader is actually ready to read three cells in succession, increased braille knowledge will enable satisfactory performance even without the additional line skip.

Based on this research, braille students 70 years of age or older can be expected to make more errors than younger students. To compensate for this, such students probably need more practice materials and more frequent instruction to discourage incorrect learning and to keep them motivated.

The finding most related to the construction of braille discrimination tests concerned the generation of foils or distractors. Although test items which contained randomly selected foils were easier both to construct and to discriminate, these may not be the best criteria for their use since braille reading requires fine discrimination among braille shapes which are often reversals or which may contain only one dot differences. To accurately test a braille reader's ability to discriminate, tests must contain these same kinds of foils, particularly the reversal which was proven to be the most difficult to distinguish.

Applications

Much of the information from this study can be used to improve future instructional braille programs for adventitiously blind adults. This information will have an immediate impact on the initial levels of Read Again, such a program now under development at the American Printing House for the Blind.

Information on foils and the difficulty of discriminating among the various types can be used in future test construction.

Limitations of the Study

The major limitation of this study, as with any study of a low incidence population, is the sample size. The small sample size, particularly of diabetics and people 70 years of age and older, could be biased. However, since efforts were made to test all possible subjects from rehabilitation agencies servicing the most clients meeting our requirements, there is no reason not to believe that this sample is representative of the adventitiously blind population learning braille.

Selection of the participants by the agency personnel could also have biased the population sample. Although the investigators encouraged the participation of all possible subjects who met the requirements of the study, in a few cases individuals might have been eliminated because of preconceived notions of the agency personnel about who could or could not participate. (Since investigators spent at least a week at each agency, it was often possible to inquire about clients who were not on the list of possible participants and sometimes to add participants or to discover that there really was some handicapping condition such as brain damage which made participation impossible.)

The elimination of participants from the study who did not have sufficient tactual sensitivity to complete the tasks may have had a slight effect on the results. Exposure to every part of the test could have identified one or some combinations of the braille size and spacing variables which they could have discriminated. However, there was no observable pattern to the work of those few who were eliminated for this reason.

Recommendations for Further Research

Since the amount of braille known did make a difference, it would be interesting to do a similar study using subjects who were even more limited in the amount of braille they knew, say 10 letters or less.

If introductory braille material is more discriminable with three spaces between characters, a study is needed to indicate when only one space between characters--the norm--can most advantageously be presented.

Likewise, additional research is needed with subjects who have had a little more experience with braille to determine whether practice makes additional line skips unnecessary as more braille shapes are combined and at what point line skips can be eliminated.

Since so many people lose their vision as they grow older, more research is needed to explore the reasons why there was such a significant difference between the tactual discriminability of the older and younger subjects in this study. Insight in this area is needed to improve the elderly's ability to learn braille and thus their quality of life. Such research might compare such things as tactual sensitivity and learning requirements of older and younger subjects.

The sense of touch is often so affected that learning braille is impossible for some blind diabetics. Further research is needed to determine how to best meet the needs of this special population.

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Appendices

Appendix A

Braille Size and Spacing Questionnaire for Participants

Name ____________________

Agency ____________________

Date ____________________

Please answer the following questions.

1. How old are you? _____

____ 10-19

____ 20-29

____ 30-39

____ 40-49

____ 50-59

____ 60-69

____ 70-79

____ 80-89

____ 90-99

2. What was the last level of education you completed?

____ less than high school If so, what grade or year? _____

____ high school

____ college

____ postgraduate If so, what degree? __________________

3. What was your occupation? ____________________

4. What was the cause of your blindness? ____________________

5. Did you lose your sight suddenly or gradually? ____________________

6. How long has it been since you lost your sight? ____________________

7. How much braille instruction have you had? ____________________

8. How much braille do you know by touch?

____ none

____ some letters If so, which ones? ____________________

____ numbers

____ other Explain. ____________________

Appendix B

Information of Subjects' Occupations

Subject ID No.	Listed Occupation	Occupational Status-1 (OCC1)	Occupational Status-2 (OCC2)
1	maintenance	1.00	1.00
2	truck driver/waiter	1.00	1.00
3	drug store manager	2.00	3.00
4	secretary	2.00	2.00
5	butler	2.00	2.00
6	custodian/stationary engineer	1.00	1.00
7	billing clerk/typist	2.00	2.00
8	clerk	2.00	2.00
9	maintenance	1.00	1.00
10	dishwasher	1.00	1.00
11	homemaker	.00	.00
12	teacher of the deaf/ secretary	2.00	3.00
13	musician-organist	2.00	3.00
14	customer engineer	2.00	2.00
15	inventory control manager	2.00	2.00
16	H.S. student	.00	.00
17	H.S. math teacher	2.00	3.00
18	spice rack packer	1.00	1.00
19	plumber/dishwasher/ janitor	1.00	1.00
20	IRS file clerk	2.00	2.00
21	senior quality engineer	2.00	3.00
22	factory worker	1.00	1.00
23	machinist/supervisor	2.00	2.00
24	nurse's aid/cashier	1.00	1.00
25	lumber handler--sawmill	1.00	1.00
26	general office worker	2.00	2.00
27	car wash worker	1.00	1.00
28	dishwasher/backroom manager/maintenance/ prep cook/bus boy	1.00	1.00
29	housewife/waitress/ factory worker	.00	.00
30	factory worker/ housecleaner	1.00	1.00
31	switchboard operator/ receptionist	2.00	2.00

Appendix B (continued)

Information of Subjects' Occupations

Subject ID No.	Listed Occupation	Occupational Status-1 (OCC1)	Occupational Status-2 (OCC2)
32	home nurse's aid/housekeeper	1.00	1.00
33	realtor	2.00	3.00
34	nurse	2.00	2.00
35	restaurant manager/ marketing research	2.00	3.00
36	small parts assembler	1.00	1.00
37	corporate sales	2.00	3.00
38	merchandise receiver & cashier	2.00	2.00
39	housekeeper/babysitting	1.00	1.00
40	stock clerk	2.00	2.00

Appendix C

Information of Subjects' Knowledge of Braille

Subject ID No.	Braille Knowledge (BK1)	Number of Braille Letters Known (BLET)
1	2.00	5
2	2.00	9
3	2.00	15
4	2.00	5
5	2.00	13
6	2.00	7
7	2.00	5
8	2.00	9
9	3.00	28
10	2.00	14
11	2.00	13
12	2.00	14
13	1.00	0
14	2.00	26
15	2.00	8
16	2.00	12
17	2.00	6
18	2.00	5
19	2.00	9
20	2.00	23
21	3.00	28
22	3.00	26
23	3.00	26
24	2.00	10
25	1.00	0
26	2.00	10
27	1.00	0
28	2.00	12
29	2.00	11
30	3.00	9
31	3.00	26
32	1.00	0
33	3.00	27
34	2.00	26
35	3.00	27
36	3.00	26

Appendix C (continued)

Information of Subjects' Knowledge of Braille

Subject ID No.	Braille Knowledge (BK1)	Number of Braille Letters Known (BLET)
37	2.00	23
38	2.00	23
39	2.00	10
40	1.00	0

Key for BK1

1 - No letters
2 - Some letters
3 - Whole alphabet

Appendix D

One-cell Braille Units Used in Test Construction

a	b	c	d	e	f	g	h	i	j
⠁	⠃	⠉	⠙	⠑	⠋	⠛	⠓	⠊	⠚
k	l	m	n	o	p	q	r	s	t
⠅	⠇	⠍	⠝	⠕	⠏	⠟	⠗	⠎	⠞
u	v	x	y	z	and	for	of	the	with
⠥	⠧	⠭	⠽	⠵	⠯	⠿	⠷	⠮	⠾
ch	gh	sh	th	wh	ed	er	ou	ow	w
⠡	⠣	⠩	⠹	⠱	⠫	⠻	⠳	⠪	⠺
st	ing	ble	ar						
⠌	⠬	⠼	⠜						

Appendix E

Braille Discrimination Test Items

Key for test items on following pages:

○ = Item containing randomly selected foils

--- = End of one-cell items (1-9) and beginning of multicell items (10-15)

___ = Braille contraction for letter combination

□ = Correct answer

〰 = Reversal foil

(-1) = Foils containing one dot less than the stimulus

(+1) = Foil containing one dot more than the stimulus

Subtest 1

1.	j	for	i(-1)	x	[✓ j]
2.	for	q(-1)	g	c	[✓ for]
3.	h	r(+1)	[✓ h]	j	of
4.	th	d(-1)	p	[✓ th]	y(+1)
5.	and	y	f	[✓ and]	p(-1)
6.	t	the	[✓ t]	j(-1)	r
7.	q	[✓ q]	g(-1)	er	c
8.	e	sh	v	m	[✓ e]
9.	v	[✓ v]	ble	b	l(-1)

10.	tsh	[✓ tsh]	osh	ba	cing
11.	gh	forh	gj	[✓ gh]	qh
12.	qst	qch	qk	[✓ qst]	erst
13.	dsi	fsi	dse	[✓ dsi]	dss
14.	ovz	kstch	[✓ ovz]	aede	forshd
15.	jinga	hinga	jingk	jua	[✓ jinga]

Subtest 2

1.	v	l(-1)	v	ble	ar
2.	ing	ing	u	st(-1)	k
③.	for	for	o	g	k
4.	n	ed	n	d(-1)	y(+1)
5.	ed	ed	n	o	and(+1)
⑥.	r	sh	ar	e	r
⑦.	h	er	h	t	ow
8.	gh	gh	ar	wh	b(-1)
9.	th	y(+1)	th	d(-1)	p

10.	bow	low	bow	bo	bi
11.	nwith	nof	nwith	dwith	dj
⑫	os	oum	blech	os	tand
⑬	wwhand	idj	wwhand	araow	buo
14.	shgch	shgst	shforch	shgch	mgch
15.	gowing	going	bowing	gowing	gowu

Subtest 3

①	i	[✓ i]	the	d	z
②	b	[✓ b]	h(+1)	ou	w
3.	p	and(+1)	th	f(-1)	[✓ p]
4.	ble	v	[✓ ble]	b	ing(-1)
5.	th	p	y(+1)	[✓ th]	d(-1)
6.	gh	b-1)	v(+1)	ar	[✓ gh]
⑦	m	z	f	ar	[✓ m]
8.	ed	[✓ ed]	f(-1)	n	p
9.	j	[✓ j]	w(+1)	t(+1)	h

10.	ub	bu	[✓ ub]	vl	ul
⑪	ei	blear	ingv	sth	[✓ ei]
12.	nsh	edsh	nu	[✓ nsh]	nk
13.	tnq	tnfor	tng	whnq	[✓ tnq]
⑭	fxp	yni	[✓ fxp]	thjd	ghny
15.	theandd	theandf	[✓ theandd]	zyd	theandth

Subtest 4

1.	u	m	[✓ u]	ing	h
2.	th	p	d(+1)	[✓ th]	y(+1)
③	h	sh	[✓ h]	x	gh
4.	and	f	y	[✓ and]	p(−1)
⑤	for	wh	z	[✓ for]	gh
6.	g	[✓ g]	of	b	er(+1)
7.	o	[✓ o]	s	ow	wh
8.	m	u	sh	c(−1)	[✓ m]
⑨	e	ou	[✓ e]	ed	i

10.	tv	tu	uv	[✓ tv]	tb
11.	oup	tp	outh	oul	[✓ oup]
⑫	owh	ythe	eq	rar	[✓ owh]
13.	withji	[✓ withji]	withjo	ofji	withje
14.	hwithq	[✓ hwithq]	hwithg	jofq	hofq
⑮	ifer	iqg	[✓ ifer]	ingzsh	ingfa

Subtest 5

1.	e	i	wh(+1)	z	[✓ e]
2.	h	j	ou(+1)	[✓ h]	r(+1)
③	a	gh	q	x	[✓ a]
④	r	ing	[✓ r]	h(-1)	wh
5.	ow	s	[✓ ow]	o	i(-1)
6.	b	1(+1)	c	g	[✓ b]
⑦	t	v	th	[✓ t]	and
8.	with	j	of	[✓ with]	t(-1)
9.	r	[✓ r]	of(+1)	h(-1)	w

10.	kar	kgh	star	char	[✓ kar]
⑪	whou	thegh	thethe	ti	[✓ whou]
12.	ua	uk	va	[✓ ua]	cha
⑬	gsing	ofqv	[✓ gsing]	sarou	zthen
14.	arothe	ghoth	[✓ arothe]	aros	aroz
15.	withep	witheth	[✓ withep]	ofip	withef

Subtest 6

1.	ch	ch	st	k	u(+1)
2.	z	o(-1)	e	the	z
3.	gh	u	ow	gh	s
4.	sh	u	x(-1)	sh	m
5.	er	g(-1)	er	n	for(+1)
6.	g	for	with	g	b
7.	ow	i(-1)	ow	o	s
8.	m	e	st	g	m
9.	n	t	with	v	n

10.	vou	vt	vou	uou	lt
11.	ethe	es	ithe	ethe	ez
12.	chv	bz	ich	rthe	chv
13.	shwhi	mwhi	shwhi	shwhe	shss
14.	jby	jland	hby	jby	jvy
15.	ingds	whvfor	dqing	ingds	erthp

Subtest 7

1.	l	for	b(-1)	v(+1)	[✓ l]
2.	w	j(-1)	[✓ w]	r	t
3.	g	[✓ g]	er(+1)	q(+1)	for
4.	sh	[✓ sh]	m	x(+1)	d
⑤	o	m	ble	[✓ o]	p
6.	ing	j	[✓ ing]	u	st
7.	ar	[✓ ar]	st(-1)	gh	wh
⑧	b	er	c	[✓ b]	q
⑨	of	[✓ of]	l	ow	i

10.	ouk	ouch	tk	[✓ ouk]	ouing
11.	ost	os	[✓ ost]	owk	och
⑫	fq	xof	[✓ fq]	thfor	ud
⑬	forln	[✓ forln]	perl	ighk	jforh
14.	stqow	stero	kqo	stoff	[✓ stqow]
15.	lom	kon	lown	lowm	[✓ lom]

Subtest 8

①	c	th	and	[✓ c]	t
2.	ar	gh	b	[✓ ar]	v
3.	i	e	ow(+1)	s(+1)	[✓ i]
4.	sh	x(+1)	[✓ sh]	c	m
5.	n	ed	and	f	[✓ n]
6.	n	m(-1)	ed	[✓ n]	th
7.	th	d(-1)	p	n	[✓ th]
⑧	r	q(+1)	e	v	[✓ r]
⑨	the	t	sh*	[✓ the]	g
10.	oua	[✓ oua]	ofa	ouk	oust
⑪	mi	kz	qu	hou	[✓ mi]
12.	nand	[✓ nand]	my	ned	yand
13.	forost	gost	foroch	gok	[✓ forost]
⑭	thmthe	boed	[✓ thmthe]	utn	lzow
15.	erver	forler	[✓ erver]	quer	erun

---

*Error in test. This should have been the one-cell contraction sh rather than the two one-cell braille units s and h.

Subtest 9

1.	ou	r	[✓ ou]	t	h(-1)
2.	ed	[✓ ed]	f(-1)	and(+1)	n
3.	ch	[✓ ch]	u(+1)	ing	st
4.	er	q	[✓ er]	g(-1)	for(+1)
⑤	q	n(-1)	ed	r(-1)	[✓ q]
⑥	z	h	[✓ z]	gh	th
7.	t	ou	j(-1)	[✓ t]	with(+1)
8.	g	for	[✓ g]	c	er(+1)
⑨	gh	b(-1)	[✓ gh]	ow	n

10.	uch	ust	uing	[✓ uch]	ach
11.	ov	oa	ok	ev	[✓ ov]
⑫	dar	ard	[✓ dar]	ge	whwh
13.	kedd	kede	[✓ kedd]	uedn	kandd
14.	vok	[✓ vok]	ghok	lok	voch
⑮	forra	gandh	forcl	ekt	[✓ forra]

Subtest 10

1.	v	ble	[✓ v]	b	gh(+1)
②	the	p	[✓ the]	ble	th
3.	q	[✓ q]	g(+1)	er	for(+1)
4.	ou	h(-1)	[✓ ou]	r	of(+1)
⑤	and	gh	m	[✓ and]	ed(-1)
⑥	d	p	j	[✓ d]	u
7.	st	u	ch	[✓ st]	ing(+1)
8.	w	[✓ w]	r	with(+1)	i (-1)
9.	ing	ch	[✓ ing]	k	u

10.	vfor	ul	vg	ufor	[✓ vfor]
11.	dq	ng	[✓ dq]	yq	nq
⑫	inger	[✓ inger]	tar	bz	ij
13.	thpx	ppx	[✓ thpx]	ypx	thpd
⑭	ofxth	oug	[✓ ofxth]	cwm	ochthe
15.	forud	forue	forur	gud	[✓ forud]

Subtest 11

1.	p	f(-1)	[✓ p]	c	th
②	er	th(-1)	[✓ er]	h	and
3.	l	b (-1)	v(+1)	[✓ l]	ble
4.	i	s(+1)	e	[✓ i]	ow(-1)
5.	gh	ar	ble	l	[✓ gh]
6.	k	u(-1)	ch	[✓ k]	ing
7.	wh	e-(1)	s	z(+1)	[✓ wh]
⑧	the	for	[✓ the]	th	g
⑨	r	o(-1)	m	e	[✓ r]

10.	chi	[✓ chi]	sti	che	chs
11.	zb	whb	theb	[✓ zb]	zl
⑫	nthe	ru	[✓ nthe]	zx	ke
⑬	zouar	lnd	[✓ zouar]	andfi	ythy
14.	svq	[✓ svq]	svg	whvq	suq
15.	ofit	withit	[✓ ofit]	ofiwith	forefor

Subtest 12

①	the	er	$\boxed{\text{the}}$	e	h
2.	y	$\boxed{\text{y}}$	and	d	for(+1)
③	e	$\boxed{\text{e}}$	a(-1)	r	b
4.	q	er	for(+1)	$\boxed{\text{q}}$	g(-1)
⑤	r	t	$\boxed{\text{r}}$	with	k
6.	ar	$\boxed{\text{ar}}$	v	l	gh
7.	i	ow(+1)	s(+1)	e	$\boxed{\text{i}}$
8.	g	c	for	$\boxed{\text{g}}$	b
9.	ing	u	st(-1)	k	$\boxed{\text{ing}}$
10.	zsh	thesh	$\boxed{\text{zsh}}$	zk	zm
11.	ingf	ingd	uf	$\boxed{\text{ingf}}$	ingp
⑫	athe	gou	eo	$\boxed{\text{athe}}$	withow
13.	ghngh	ghnar	arnar	$\boxed{\text{ghngh}}$	lngh
14.	djth	$\boxed{\text{djth}}$	fjth	djp	dip
⑮	iny	$\boxed{\text{iny}}$	kofv	awhg	pfgh

APH American Printing House For The Blind Incorporated

Appendix F

Introduction and Participation Agreement

The American Printing House for the Blind is a nonprofit organization that has, for over 100 years, been making special materials for people with little or no vision. Recently, we have developed a program named "Read Again" to help people who have previously read print learn to use braille. In order to complete the development of this program, we need more information about the usefulness of braille in different sizes and with different spacing. To help us with this study, we are seeking participants who are just beginning to learn braille. Actually, the less braille you know the better.

Participation time will vary with the individual from approximately 1 1/2 to 2 1/2 hours. You will be asked a few questions about yourself and your knowledge, if any, of braille. Then you will be given sheets with lines of raised shapes or dotted (braille) shapes which will vary in size and spacing. In each case the task will be for you to find the shape among four choices that matches the first shape in a line. No one is expected to get every item correct. If you would be willing to help us with this important study, please sign your name near the bottom of this page.

Appendix G

Practice Items

Page 1

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Page 2

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Appendix H

Directions for Administering the Test

Directions for data collection

(After the person has signed a form agreeing to participate in the study and a questionnaire has been completed, give the participant the set of practice sheets.) On the first line of this practice set you will find five raised shapes. See if you can find the five shapes in the line. You may use both hands. (Give help if needed.)

Examine the first shape in the line. (Guide the person to the first line, pointing out the staple as you go.) See if you can find another shape in the line that matches the first shape. (Give help if needed.) Mark a line through the shape that matches the first shape in the line. You can use your finger as a guide. (Give help if necessary.)

Do the rest of the lines on this page and the next page the same way. Remember to mark the shape that matches the first shape in each line. (If necessary, repeat the detailed directions given in paragraph two until the participant seems to understand what is expected. Also, the participant may need to be reminded to go on to the next page.)

(When the participant has finished the four training items on these two pages, decide whether he or she seems to understand the directions and has sufficient tactual sensitivity to continue with the test items. If not, thank the person for his or her willingness to participate before dismissal. If so, go on with the directions.)

Now I will give you 12 more sets of items to do one set at a time. Each set will have 15 lines of dotted or braille shapes. You are to look at the first one in each line and then find the other one in that line that matches it. Mark that shape. The last shapes you will be matching are made up of more than one part. Sizes and spaces are different in each set. Be sure you find the first and last lines on the page. Your accuracy and time will be noted on each set. No one is expected to get every item correct, but you should try to mark something that you think matches in each line. Are there any questions before I give you the first set? (Answer any questions that arise before giving the participant the first set.)

(Begin timing the first set as soon as it is given to the participant. Note the time when the participant finished on the first page of the set.)

(If a participant skips an item, count the item wrong and add the average amount of time required to do the other items in the set to the time for that set.)

(Continue on with the other eleven sets in the same way. When appropriate, assure the participants that their performance on these tasks is not indicative of their ability to learn braille. Breaks may be taken between sets if necessary.)

(When all 12 sets have been completed, thank the person for participating and be sure all test materials are identified with the participant's number and/or name and filed.)

Tables

Table 1

Frequency Distribution and Descriptive Statistics on Location, Age, and Education of Subjects

Variable	f	%
Location		
The Greater Pittsburgh Guild for the Blind	13	33
The Carroll Center for the Blind in Massachusetts	10	25
Michigan Rehabilitation Center for the Blind	6	15
Kentucky Rehabilitation Center for the Blind	6	15
Florida Association of Workers for the Blind, Inc.	5	12
Age in Years[a]		
74 - 83	6	15
64 - 73	3	7
54 - 63	7	18
44 - 53	7	18
34 - 43	4	10
24 - 33	10	25
17 - 23	3	7
Educational level in years[b]		
17 - 18	3	7
13 - 14	9	22
12	17	43
9 - 11	5	13
6 - 8	6	15

Note. n = 40

[a] Mean = 48.2, Median = 47.0, SD = 18.5, Range = 67.0, Skewness = 0.2

[b] Mean = 11.8, Median = 12.0, SD = 2.7, Range = 13.0, Skewness = 0.0

Table 2

Frequency Distribution on Variables Occupational Status 1 and Occupational Status 2 for Subjects

Variable	Code	f	%
Occupational Status 1 (OCC1)			
Skilled	2	21	53
Unskilled	1	16	40
Other	0	3	7
Occupational Status 2 (OCC2)			
Skilled/Professional	3	8	20
Skilled/Managerial	2	13	33
Unskilled	1	16	40
Other	0	3	7

Note. For both variables, the category "Other" included one person with no occupation and two persons who identified themselves as homemakers.

In Appendix A, the code value (i.e., numbers 0, 1, 2, 3) used for variables OCC1 and OCC2 are shown for each of the 40 subjects in the study.

Table 3

Frequency Distribution and Descriptive Statistics on Causes of Blindness and Number of Years Diabetic Subjects Had Been Identified Diabetic

Variable	f	%
Causes of blindness or vision problems		
Diabetes	11	28
Glaucoma	9	23
Cataracts	5	12
Macular Degeneration	4	10
Retinitis Pigmentosa	4	10
Other	7	17
Years of diabetes reported by diabetic subjects[a]		
35	1	9
25	1	9
24	1	9
23	1	9
17	1	9
15	1	9
11	1	9
8	1	9
2	1	9
Missing	2	18

[a] n = 11, Mean = 17.8, Median = 17.0, SD = 10.1, Range = 34.0, Skewness = 0.2.

Table 4

Frequency Distribution and Descriptive Statistics on Suddenness of Sight Loss and Number of Years Since Loss Among Subjects

Variable	f	%
Speed of sight loss		
Gradual	31	78
Sudden	9	22
Years of sight loss[a]		
26	1	3
9 - 15	4	10
4 - 7	7	18
3	6	15
2	7	18
1.5 or less	11	17
Missing	4	10

---

[a] Mean = 4.1, Median = 2.5, SD = 5.0, Range = 26.0, Skewness = 0.2.

Table 5

Frequency Distribution on Variables Braille Knowledge and Number of Braille Letters Known Among Subjects

Variable	Code	f	%
Braille Knowledge (BK1)			
Whole alphabet	3	9	23
Some letters	2	26	65
No letters	1	5	12
Number of Braille Letters Known (BLET)			
28		2	5
27		2	5
26		6	15
23		3	8
15		1	3
14		2	5
13		2	5
12		2	5
11		1	3
10		3	8
9		4	10
8		1	3
7		1	3
6		1	3
5		4	10
0		5	13

Note. For the variable BLET, the number of letters claimed to be known by the person were counted. Persons knowing more than the alphabet (for example alphabet + punctuation) were classified as a number greater than 26. The three persons stating that they knew "some" letters were arbitrarily classified as knowing 9. Appendix B shows raw data for each subject on variables BK1 and BLET.

Table 6

Mean Number Correct on 12 Braille Tests

		Item type				
	Test code	All items	1-cell items	2-cell items	3-cell items	2 & 3-cell items
1.	S11	9.10	6.08	1.60	1.43	3.03
2.	S21	8.13	5.43	1.45	1.25	2.70
3.	S31	8.90	5.80	1.63	1.48	3.10
4.	S12	9.03	5.90	1.50	1.63	3.13
5.	S22	8.73	5.85	1.33	1.55	2.88
6.	S32	8.98	5.98	1.63	1.38	3.00
7.	E11	9.05	6.05	1.45	1.55	3.00
8.	E21	9.00	5.98	1.65	1.38	3.03
9.	E31	8.75	5.85	1.53	1.38	2.90
10.	E12	9.25	6.05	1.63	1.58	3.20
11.	E22	9.40	6.10	1.75	1.55	3.30
12.	E32	8.78	5.70	1.33	1.75	3.08

Note. For the test code, S = standard size braille, E = enlarged braille, the first digit is the number of spaces between characters, and the second digit is the number of skips between lines.

Table 7

Analysis of Variance for Number Correct on 12 Braille Tests: All Items and One-Cell Items

Source of variance	Item type			
	All items		1-cell items	
	F	p	F	p
Size	1.78	.19	.87	.37
Space	1.45	.24	1.09	.34
Skip	1.77	.19	.37	.55
Size x space	2.91	.06	1.25	.29
Size x skip	.00	.98	.29	.60
Space x skip	.63	.54	.54	.59
Size x space x skip	.20	.82	.46	.63

Table 8

Analysis of Variance for Number Correct on 12 Braille Tests: Two-Cell Items, Three-Cell Items, and Two- and Three-Cell Items Combined

	Item type					
Source of variance	2-cell items		3-cell items		2-& 3-cell items	
	F	p	F	p	F	p
Size	.24	.63	1.09	.30	.94	.34
Space	.03	.98	.73	.49	.35	.70
Skip	.13	.72	5.55*	.02	1.72	.20
Size x space	4.63	.01*	.18	.84	1.76	.18
Size x skip	.72	.40	.16	.69	.55	.46
Space x skip	.28	.76	.30	.73	.30	.74
Size x space x skip	1.31	.28	2.33	.11	.10	.89

*$p < .05$.

Table 9

Mean Number of Minutes to Complete 12 Braille Tests

	Test code	Mean minutes
1.	S11	10.96
2.	S21	10.76
3.	S31	9.94
4.	S12	10.45
5.	S22	10.86
6.	S32	10.37
7.	E11	12.27
8.	E21	11.88
9.	E31	11.29
10.	E12	11.73
11.	E22	11.04
12.	E32	10.58

Note. For the test code, S = standard size braille, E = enlarged braille, the first digit is the number of spaces between characters, and the second digit is the number of skips between lines.

Table 10

Analysis of Variance for Mean Number of Minutes to Complete 12 Braille Tests

Source of variance	F	p
Size	7.37*	.01
Space	3.24*	.05
Skip	2.01	.06
Size x space	.41	.64
Size x skip	2.66	.11
Space x skip	.17	.84
Size x space x skip	.30	.71

*$p < .05$.

Table 11

Mean Number Correct on 12 Braille Tests: Comparisons of Diabetic Vs. Nondiabetic and of Younger Vs. Older Subjects

		Comparison groups			
	Test code	Nondiabetic	Diabetic	Younger	Older
1.	S11	9.00	9.36	9.85	4.83
2.	S21	8.07	8.27	8.68	5.00
3.	S31	8.66	9.55	9.74	4.17
4.	S12	8.93	9.27	9.85	4.33
5.	S22	9.03	7.91	9.35	5.17
6.	S32	8.86	9.27	9.59	5.50
7.	E11	9.07	9.00	9.56	6.17
8.	E21	9.00	9.00	9.91	3.83
9.	E31	8.86	8.46	9.62	3.83
10.	E12	9.21	9.36	10.03	4.83
11.	E22	9.24	9.82	10.12	5.33
12.	E32	8.90	8.46	9.53	4.50

Note. For the test code, S = standard size braille, E = enlarged braille, the first digit is the number of spaces between characters, and the second digit is the number of skips between lines.

The numbers of subjects were as follows: nondiabetic, n = 29; diabetic, n = 11; younger (i.e., age $<$ 70 years), n = 34; older (i.e., age $\geq$ 70 years), n = 6.

Table 12

Mean Number of Minutes to Complete 12 Braille Tests: Comparisons of Diabetic Vs. Nondiabetic and of Younger Vs. Older Subjects

	Test code	Comparison groups			
		Nondiabetic	Diabetic	Younger	Older
1.	S11	11.24	10.25	10.22	15.21
2.	S21	10.96	10.22	10.75	10.83
3.	S31	10.30	8.97	9.58	11.94
4.	S12	10.46	10.43	10.23	11.71
5.	S22	10.89	10.78	10.23	14.41
6.	S32	10.81	9.22	9.74	13.94
7.	E11	12.95	10.45	11.32	17.63
8.	E21	12.20	11.06	10.82	17.89
9.	E31	11.38	11.02	10.97	13.10
10.	E12	12.55	9.57	11.09	15.36
11.	E22	11.15	10.75	10.66	13.13
12.	E32	11.03	9.37	10.10	13.26

Note. For the test code, S = standard size braille, E = enlarged braille, the first digit is the number of spaces between characters, and the second digit is the number of skips between lines.

The numbers of subjects were as follows: nondiabetic, n = 29; diabetic, n = 11; younger (i.e., age $<$ 70 years), n = 34; older (i.e., age $\geq$ 70 years), n = 6.

Table 13

Mean Number of Errors on 12 Braille Tests

		Type of error				
	Test code	Top line skip	Medial line skip	Bottom line skip	Multiple answers	Selection of 1st shape
1.	S11	.05	.55	.00	.13	.03
2.	S21	.18	1.13	.00	.13	.00
3.	S31	.15	.93	.10	.08	.00
4.	S12	.05	.08	.00	.05	.03
5.	S22	.03	.20	.05	.25	.03
6.	S32	.15	.20	.03	.38	.00
7.	E11	.18	.25	.08	.20	.10
8.	E21	.18	.45	.03	.25	.08
9.	E31	.03	.60	.05	.35	.05
10.	E12	.08	.05	.15	.20	.00
11.	E22	.23	.18	.18	.38	.05
12.	E32	.10	.18	.08	.25	.03

Note. For the test code, S = standard size braille, E = enlarged braille, the first digit is the number of spaces between characters, and the second digit is the number of skips between lines.

Table 14

Analysis of Variance for Mean Number of Medial Line Skip Errors Made in Completing 12 Braille Tests

Source of variance	F	p
Size	7.50*	.01
Space	7.52*	.00
Skip	33.12*	.00
Size x space	1.08	.36
Size x skip	9.56*	.00
Space x skip	2.89	.06
Size x space x skip	1.35	.27

*$p < .05$.

Table 15

Item Analysis Statistics on 12 Braille Tests: All 15 Items per Test Included

		Item statistics					
	Test code	Mean	SD	Mean item mean	Minimum item mean	Maximum item mean	Alpha coefficient
1.	S11	9.10	2.92	.61	.35 (11 & 15)	.88 (8)	.66
2.	S21	8.13	2.81	.54	.28 (14)	.83 (1)	.60
3.	S31	8.90	3.32	.59	.20 (13)	.83 (1)	.75
4.	S12	9.03	3.21	.60	.40 (14)	.78 (4 & 5)	.71
5.	S22	8.73	3.06	.58	.25 (10)	.98 (3)	.70
6.	S32	8.98	3.29	.60	.25 (14)	.83 (7)	.74
7.	E11	9.05	3.23	.60	.28 (14)	.93 (8)	.74
8.	E21	9.00	3.64	.60	.25 (13)	.85 (1)	.80
9.	E31	8.75	3.79	.58	.33 (14)	.88 (9)	.82
10.	E12	9.25	3.48	.62	.28 (10)	.85 (2)	.78
11.	E22	9.40	3.37	.63	.40 (15)	.88 (3)	.76
12.	E32	8.78	3.52	.59	.15 (11)	.90 (3)	.80

Note. For the test code, S = standard size braille, E = enlarged braille, the first digit is the number of spaces between characters, and the second digit is the number of skips between lines. In parentheses are shown the item number(s) associated with the minimum and maximum item means. For example, on test 1, the minimum item mean of .35 was obtained on items 11 and 15.

Table 16

Item Analysis Statistics on 12 Braille Tests: Nine Items per Test (Only Single Cell Items) Included

		Item statistics					
	Test code	Mean	SD	Mean item mean	Minimum item mean	Maximum item mean	Alpha coefficient
1.	S11	6.08	2.08	.68	.50 (6 & 7)	.88 (8)	.63
2.	S21	5.43	1.85	.60	.38 (5)	.83 (1)	.46
3.	S31	5.80	2.38	.64	.45 (6)	.83 (1)	.74
4.	S12	5.90	2.25	.66	.43 (8)	.78 (4 & 5)	.69
5.	S22	5.85	1.96	.65	.43 (8)	.98 (3)	.57
6.	S32	5.98	2.31	.66	.48 (2)	.83 (7)	.71
7.	E11	6.05	2.24	.67	.55 (6)	.93 (8)	.70
8.	E21	5.93	2.39	.66	.50 (4)	.85 (1)	.74
9.	E31	5.85	2.35	.65	.50 (1)	.88 (9)	.73
10.	E12	6.05	2.37	.67	.53 (8)	.85 (2)	.74
11.	E22	6.10	2.26	.68	.45 (6)	.88 (3)	.72
12.	E32	5.70	2.32	.63	.30 (9)	.90 (3)	.73

Note. For the test code, S = standard size braille, E = enlarged braille, the first digit is the number of spaces between characters, and the second digit is the number of skips between lines. In parentheses are shown the item number(s) associated with the minimum and maximum item means. For example, on test 1, the minimum item mean of .50 was obtained on items 6 and 7.

Table 17

Easiest Test Items: Those Items Answered by .80 or More Subjects

	Item			
Test code	Subtest number	Item number	Proportion of subjects answering item correctly	Number of subjects answering item correctly
S22	5	3	.975	39
E11	7	8	.925	37
E32	12	3	.900	36
S11	1	8	.875	35
E31	9	9	.875	35
E22	11	3	.875	35
E11	7	9	.850	34
E21	8	1	.850	34
E31	9	3	.850	34
E12	10	2	.850	34
S21	2	1	.825	33
S31	3	1	.825	33
S32	6	7	.825	33
S31	3	4	.800	32
S31	3	14	.800	32
S32	6	8	.800	32
E21	8	3	.800	32
E22	11	4	.800	32
E32	12	12	.800	32

Note. For the test code, S = standard size braille, E = enlarged braille, the first digit is the number of spaces between characters, and the second digit is the number of skips between lines.

Table 18

Hardest Test Items: Those Items Answered by .40 or Fewer Subjects

Item				
Test code	Subtest number	Item number	Proportion of subjects answering item correctly	Number of subjects answering item correctly
S21	2	2	.400	16
S21	2	11	.400	16
S12	4	14	.400	16
S32	6	13	.400	16
E22	11	15	.400	16
S21	2	5	.375	15
S22	5	15	.375	15
E32	12	10	.375	15
S11	1	11	.350	14
S11	1	15	.350	14
E31	9	14	.325	13
E32	12	9	.300	12
E11	7	10	.300	12
E12	10	15	.300	12
S21	2	14	.275	11
E11	7	14	.275	11
E12	10	10	.275	11
S22	5	10	.250	10
S32	6	14	.250	10
E21	8	13	.250	10
S31	3	13	.200	8
E32	12	11	.150	6

Note. For the test code, S = standard size braille, E = enlarged braille, the first digit is the number of spaces between characters, and the second digit is the number of skips between lines.

Table 19

Average Proportion Correct for Items with Randomly Chosen Foils and Items with Nonrandomly Chosen Foils

	Test code	Average proportion correct		
		Random foil items	Nonrandom foil items	t
1.	S11	.6750	.6750	0.00
2.	S21	.6750	.5667	2.28
3.	S31	.7500	.5917	2.75
4.	S12	.7083	.6292	1.47
5.	S22	.7917	.5792	4.52*
6.	S32	.7333	.6292	3.01*
7.	E11	.7833	.6167	4.16*
8.	E21	.7250	.6333	1.86
9.	E31	.7083	.6208	2.29
10.	E12	.7583	.6292	3.11*
11.	E22	.6167	.7083	-1.76
12.	E32	.7667	.5667	4.68*
	Total	.7243	.6205	8.05*

Note. For the test code, S = standard size braille, E = enlarged braille, the first digit is the number of spaces between characters, and the second digit is the number of skips between lines.

With 13 tests, Bonferroni adjusted alpha = .05/13 = .0039. Thus, alpha for the set of 13 tests is .05.

*$p < .0039$, one-tail test, 39 df.

Table 20

Attractiveness of R = Reversal Foil

	Type of item				
	R total	R alone	R with -1	R with +1	R with -1 & +1
Number of items	57	11	18	16	12
Number of times R foil was chosen	347	61	142	77	67
Number of possible choices	2280	440	720	640	480
Proportion of possible choices for which R foil was chosen	.152	.139	.197	.120	.140

Note. R = Reversal foil, -1 = dropped dot foil, +1 = added dot foil.

Table 21

Attractiveness of -1 = Dropped Dot Foil

	Type of item				
	-1 total	-1 alone	-1 with R	-1 with +1	-1 with R & +1
Number of items	44	9	18	5	12
Number of times -1 foil was chosen	198	56	78	25	39
Number of possible choices	1760	360	720	200	480
Proportion of possible choices for which -1 foil was chosen	.113	.156	.108	.125	.081

Note. R = Reversal foil, -1 = dropped dot foil, +1 = added dot foil.

Table 22

Attractiveness of +1 = Added Dot Foil

	Type of item				
	+1 total	+1 alone	+1 with R	+1 with -1	+1 with R & -1
Number of items	42	9	16	5	12
Number of times +1 foil was chosen	238	55	98	18	67
Number of possible choices	1680	360	640	200	480
Proportion of possible choices that +1 foil was chosen	.141	.153	.153	.090	.140

Note. R = Reversal foil, -1 dropped dot foil, +1 = added dot foil.

Table 23

Relative Attractiveness of Foils: Rank Order from Most Often Chosen to Least Often Chosen

Foil	Proportion of times chosen
R with -1	.197
-1 alone	.156
+1 alone	.153
+1 with R	.153
R total	.152
+1 total	.141
+1 with R and -1	.140
R with +1 and -1	.140
R alone	.139
-1 with +1	.125
R with +1	.120
-1 total	.113
-1 with R	.108
+1 with -1	.090
-1 with R and +1	.081

Note. R = Reversal foil, -1 = dropped dot foil, +1 = added dot foil.

Figures

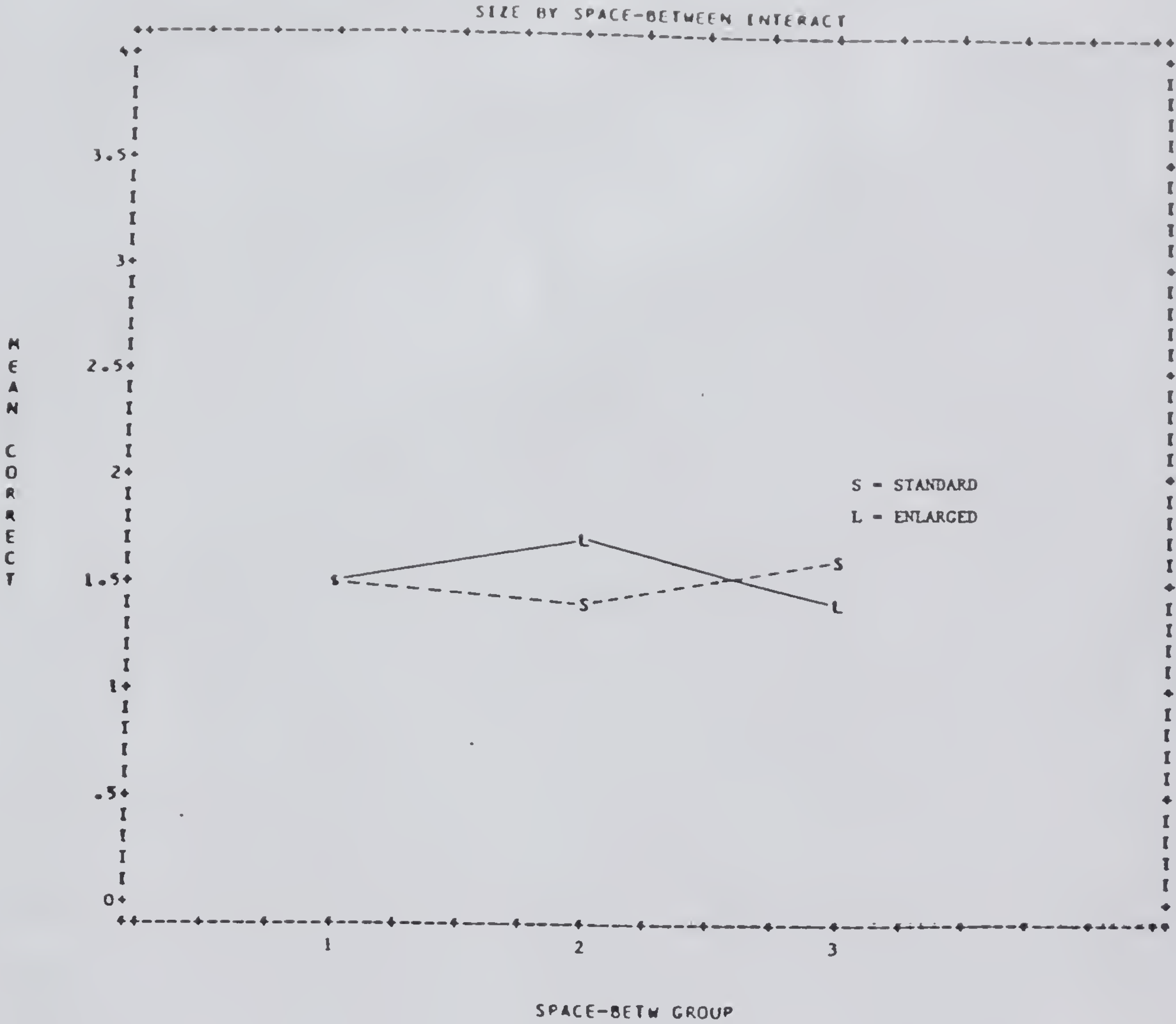

Figure 1. Mean number of two-cell items correct: interaction between size of braille and number of spaces between characters.

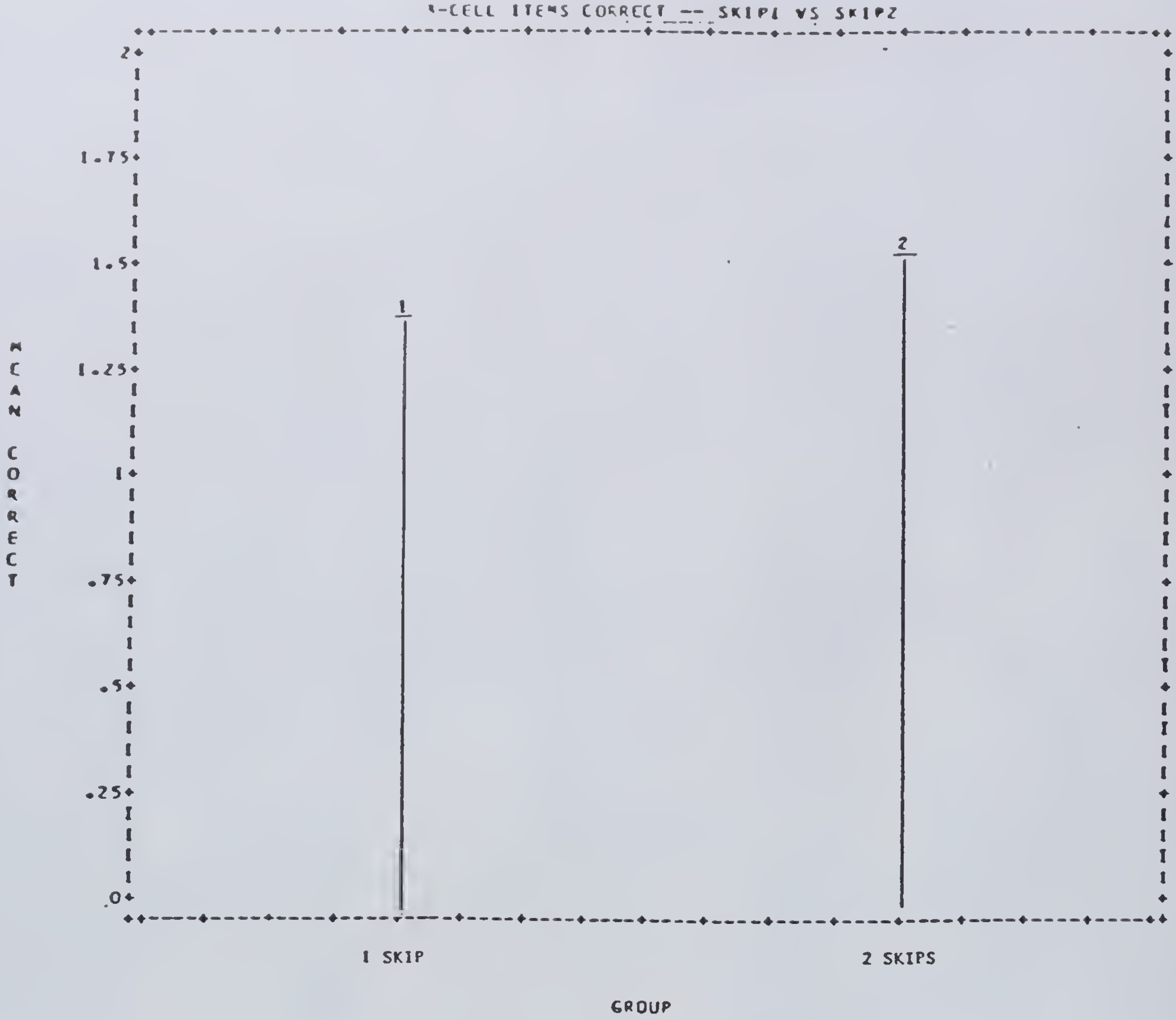

Figure 2. Mean number of three-cell items correct for tests with one skip between lines and tests with two skips between lines.

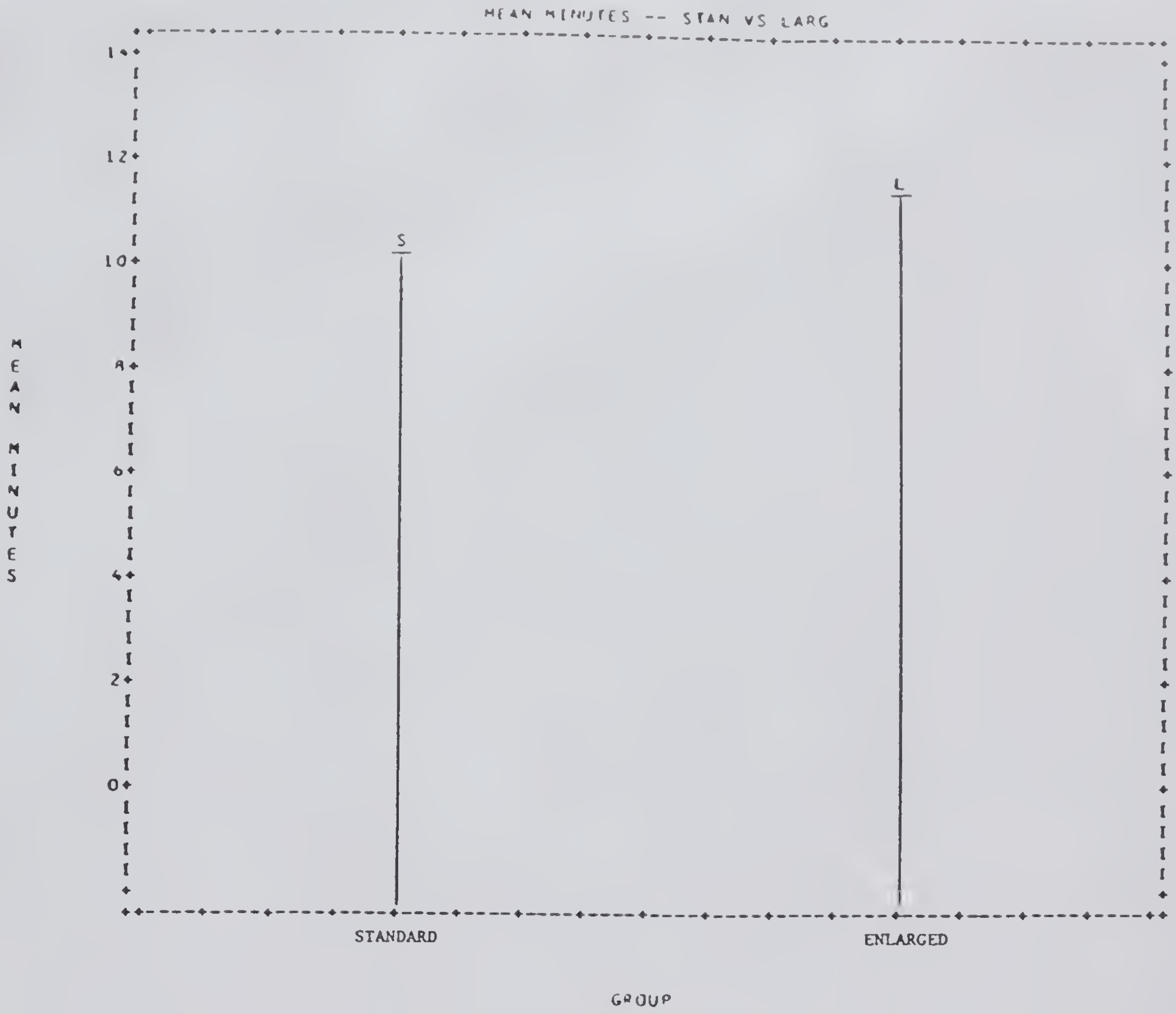

Figure 3. Mean number of minutes to read tests in standard size braille and tests in enlarged braille.

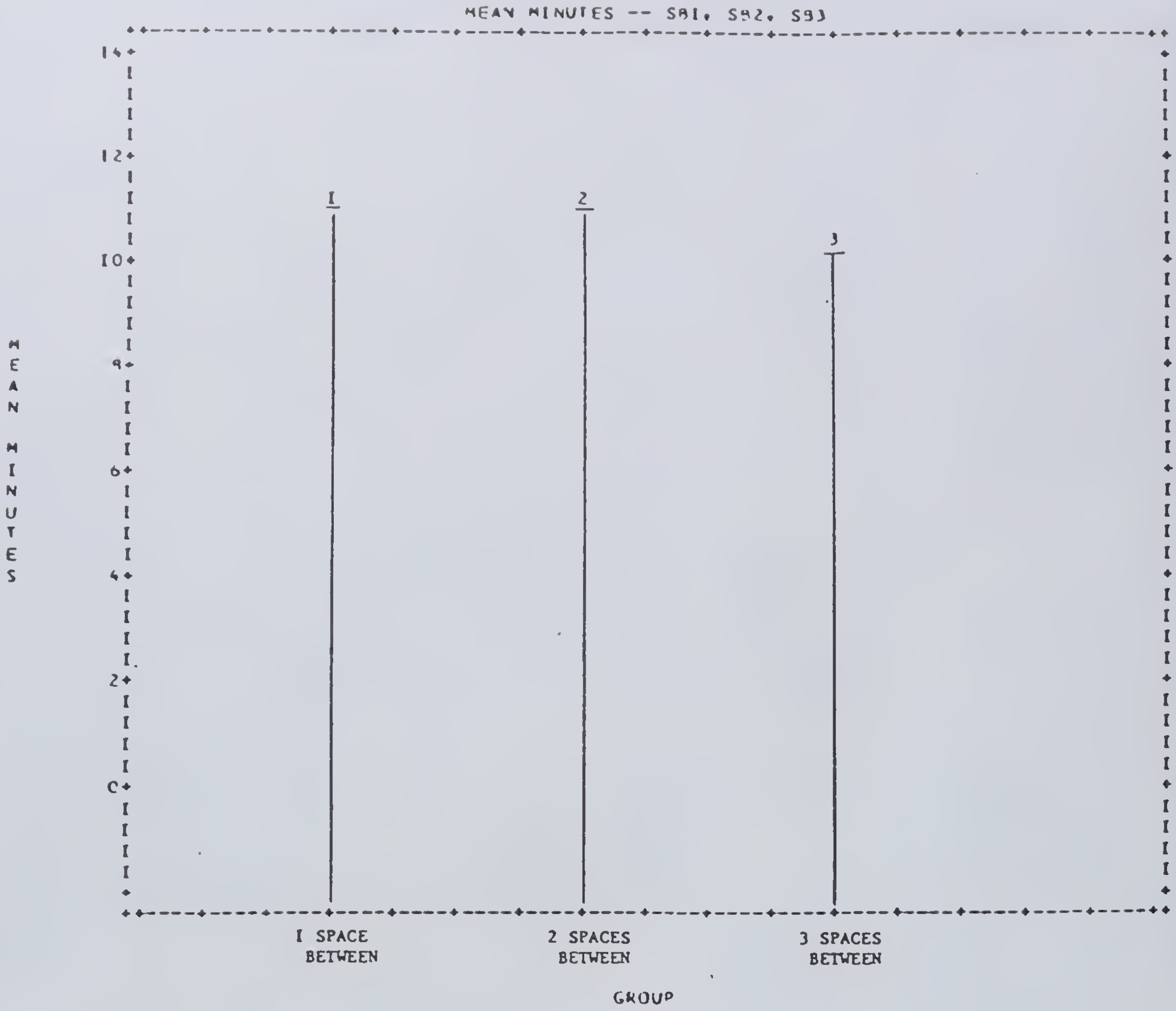

Figure 4. Mean number of minutes to read tests with one, two, and three spaces between braille characters.

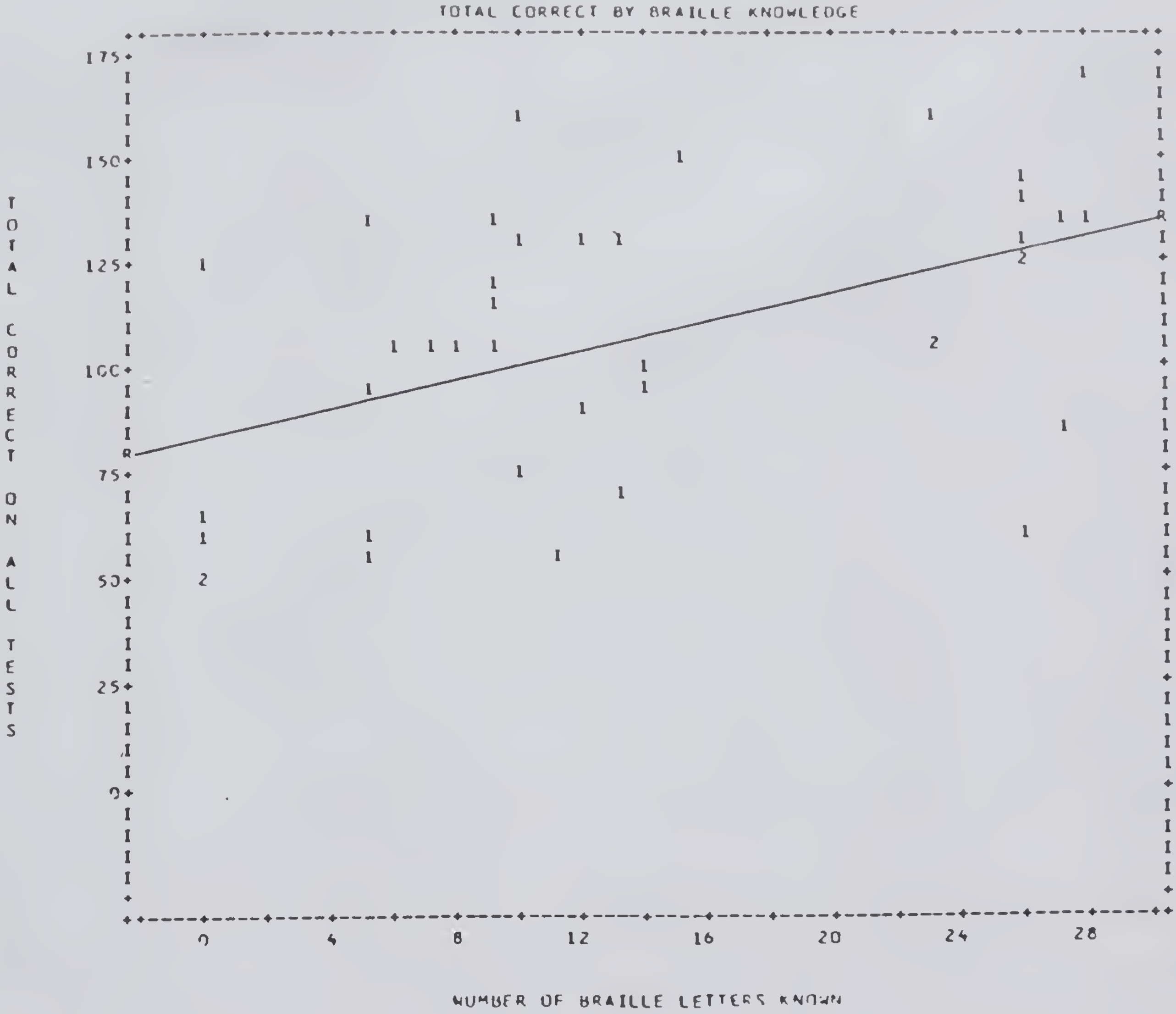

Figure 5. Scatter diagram showing relationship between Number of Braille Letters Known and Total Correct on All Braille Tests ($r = .47$, $p < .001$).

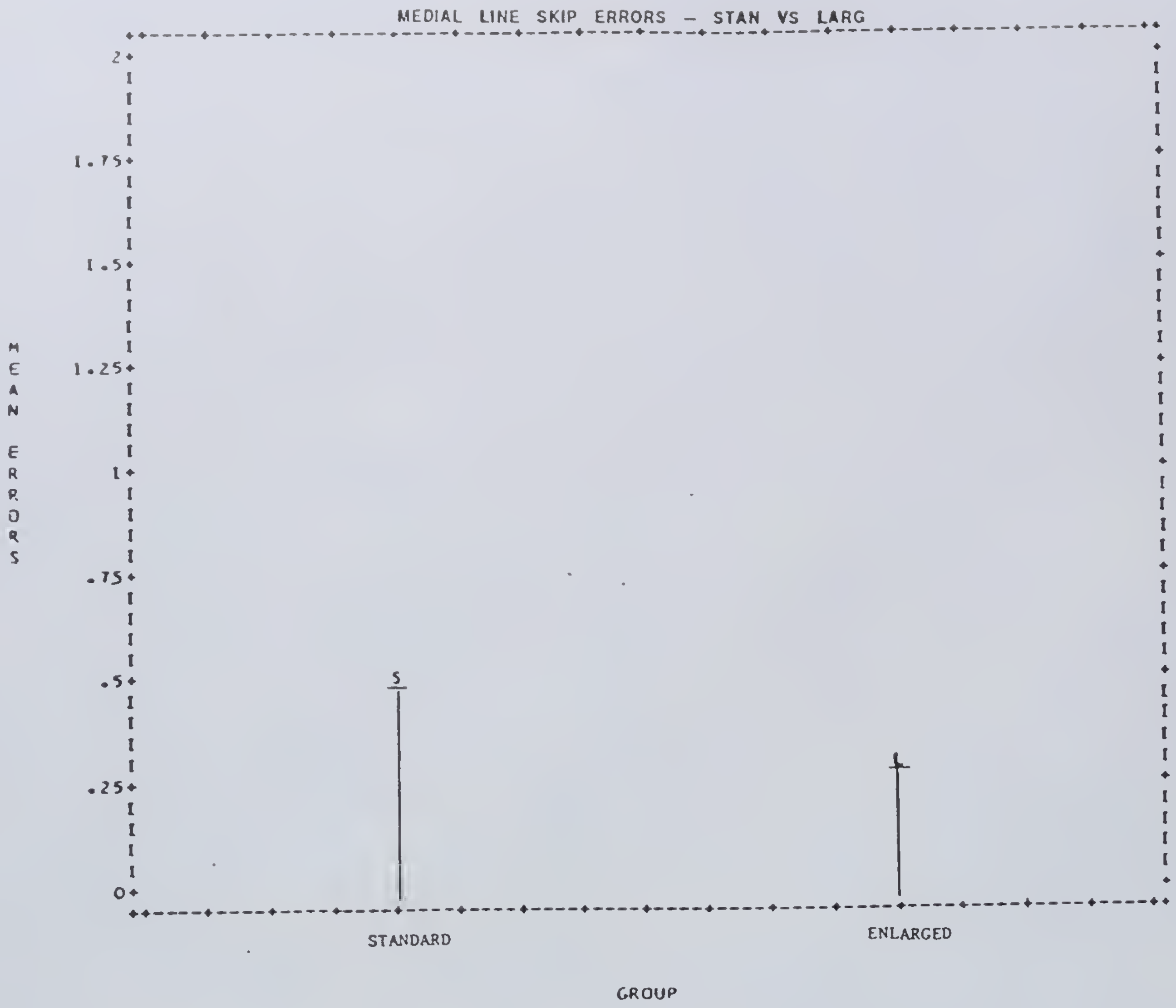

Figure 6. Mean number of medial line skip errors on tests using standard size braille and tests using enlarged braille.

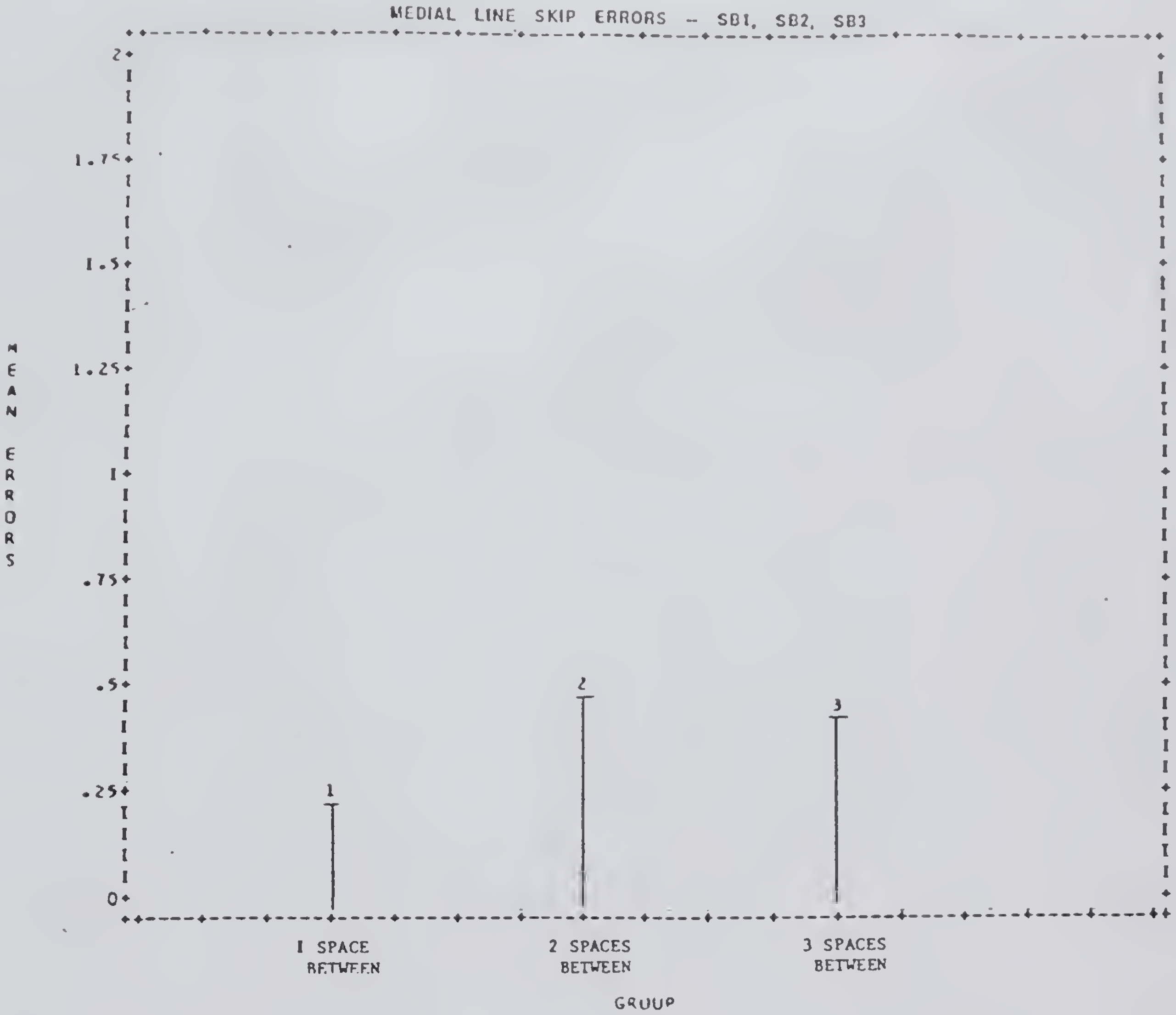

Figure 7. Mean number of medial line skip errors on tests using one, two, and three spaces between braille characters.

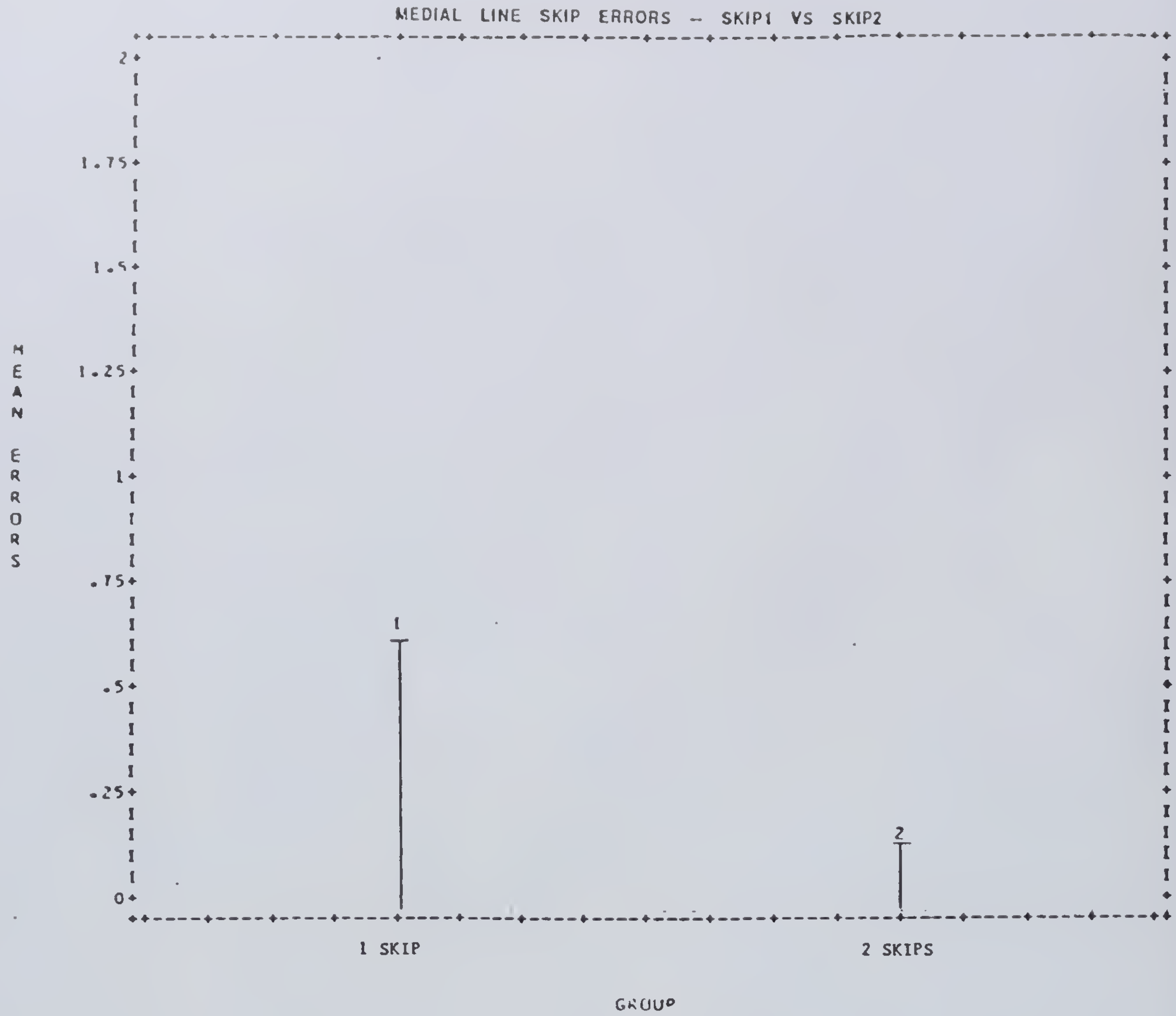

Figure 8. Mean number of medial line skip errors on tests using one and two skips between lines.

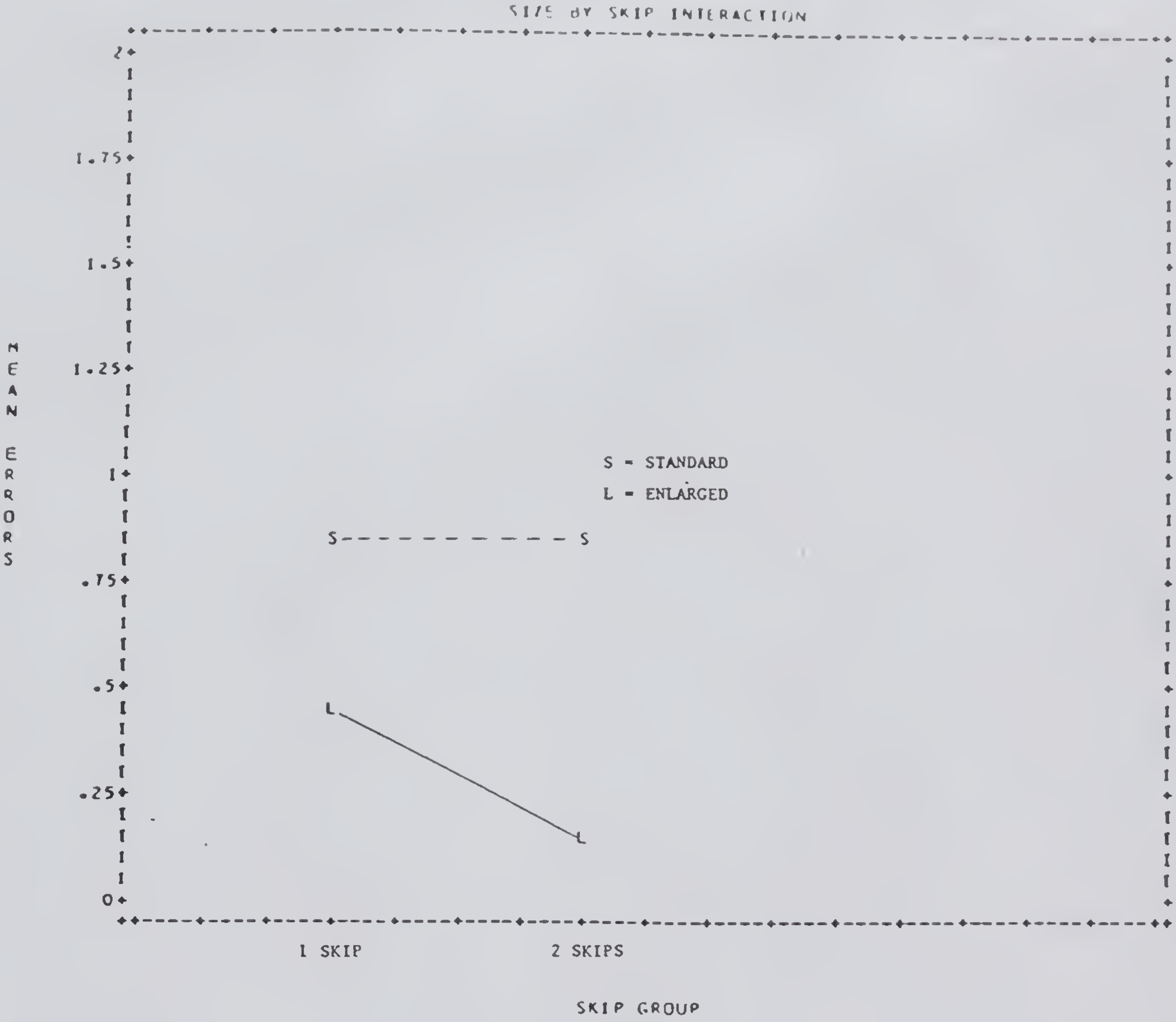

Figure 9. Mean number of medial line skip errors: interaction between size of braille and number of skips between lines.